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EDITED BY
A. H. G. ALSTON, B.A. (Oxon), F.L.S.

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CONTENTS

	Page
Lewis, F.—The Altitudinal Distribution of the Ceylon Endemic Flora	1
Petch, T.—Additions to Ceylon Fungi, IV	131
Livera, E. J.—Some New Ceylon Plants	139
Livera, E. J.—Aeginetiaceae. A New Natural Family of Flowering Plants	145
Petch, T.—Revisions of Ceylon Fungi, Part VIII	161
Petch, T. and Ragunathan, C.—The Fungi associated with disease in Vanilla	181
Bertus, L. S.—Grey Blight of Tea and Coconut—A Comparative Study	197
Lester-Smith, W. G.—Some Observation on the Ospores of Phytophthora species	243
Park, M.—Some investigations into conditions affecting the parasitism of Rhizoctonia solani Kühn	259
Park, M.—A Fusarium disease of Dadap (Erythrina lithosperma)	275
Bertus, L. S.—Fruit Diseases of Chillies	295
Livera, E. J.—Notes on some Symplocaceae of Ceylon	315

ERRATA.

(To face p. 1, Ceylon Journal of Science, Sect. A, Vol. X.)

P. 9, l. 4.—For "3 endemics" read "2 endemics."

P. 13, l. 3.— For "these" read "here." l. 4 delete "here"

P. 49.—Opposite *Acrotrema Gardneri* move x from 3,000 ft. to 1,000 ft. column.

Opposite *Uvaria macropoda* insert x in Eastern 2,000 ft.

Opposite *Unona elegans* delete x from Eastern 2,000 ft.

P. 51.—Opposite *Xylopia parviflora* move x from Eastern 4,000 ft. to Eastern 1,000 ft.

Opposite *Xylopia nigricans* move x from Eastern 3,000 ft. to Eastern 1,000 ft.

Opposite *Goniothalamus Hookeri* move x one column left.

P. 53.—Opposite *Stellaria drymarioides* move x from 5,000 ft. to 4,000 ft. column.

P. 55.—Opposite *Dipterocarpus zeylanicus* and *Doona cordifolia* move x's from Eastern 4,000 ft. to Eastern 3,000 ft.

P. 57.—Opposite *Stemonoporus rigidus* insert x in Western 2,000 ft. column.

P. 59.—Opposite *Elaeocarpus obovatus, montanus, zeylanicus* and *glandulifera,* move x's one column left.

P. 69.—Opposite *Serpicula zeylanica* delete x's and insert Western 6,000 and 7,000 ft. and Eastern 6,000 ft.

Opposite *Eugenia cylindrica* insert x in Western 2,000 ft

P. 71.—Opposite *Eugenia phillyraeoides, rotundata, Mabaeoides,* and *aprica,* move x's one column right.

P. 77.—Opposite *Heptapleurum emarginatum,* move x's one column left.

P. 79.—Opposite *Hedyotis nodulosa, cinereo-viridis, rhinophylla, Lessertiana, quinquenervia, Gardneri, Lawsoniae, inamoena, cyanescens,* and *Leucocodon reticulatum,* move x's one column right.

Opposite *Anotis nummulariformis* insert x in Eastern 5,000 ft.

Opposite *Urophyllum zeylanicum,* move x's one column left.

P. 89.—Opposite *Symplocos cordifolia* move final x one column left.

P. 95.—Opposite *Christisonia albida* insert x in Western 6,000 ft.

Opposite *Chirita zeylanica* insert x in Eastern 3,000 ft.

P. 99.—Opposite *Justicia Hookeriana* delete x in 3,000 ft. column.

P. 101.—Opposite *Peperomia pseudo-rhombia* move x from 5,000 to 4,000 ft Eastern

P. 107.—Opposite *Cleistanthus pallidus,* delete x in Western 4,000 ft.

Opposite *Phyllanthus oreophyllus, hakgalensis,* and *affinis,* move x's one column left

P. 109.—Opposite *Hemicyclia lanceolata,* insert x in Western 1,000 ft.

P. 113.—Opposite *Cirrhopetalum Macraei,* insert x in Eastern 3,000 ft.

P. 117.—Opposite *Podochilus saxatilis,* insert x in Eastern 2,000 ft.

P. 121.—Opposite *Cyanotis zeylanica,* insert x's in Western 4,000 ft. and 6,000 ft.

Opposite *Areca concinna,* remove ¼ from 1,000 to fruit column and substitute x.

P. 125.—Opposite *Arisaema filicandatum,* remove x one column right.

P. 127.—Opposite *Isachne multiflora* insert x in Eastern 5,000 ft.

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The Altitudinal Distribution of the Ceylon Endemic Flora

BY

F. Lewis, F.L.S.

It is proposed in this paper to give a brief sketch of our endemic flora only, exclusive of cryptogams with an attempt to place the individuals in the position of their altitudinal distribution.

I have been guided so far in this effort by the data I have obtained from *Trimen's Flora of Ceylon*, and I follow his classification, as well as his nomenclature. In some instances I have assigned altitudinal location from my own personal observations, but these I have not specially recorded, as I think it would be superfluous to do so.

I find, at the very outset of the work, that much more data are required with regard to the flora of our eastern section than that of the west, so that I feel conscious that the tables at the end of this paper are far from complete or satisfactory, as I am not aware of the existence of an exhaustive botanical exploration of certain ranges of mountains, by which can be determined the flora of those localities, for purposes of comparison with the flora of the westward slopes. In saying this, I refer in particular to the great mass of hills extending from the Rangalla District in an easterly direction to, say, the Mahaweliganga river. I have personally explored the summit of the "Knuckles" Peak (6,112 ft.), and the country at the foot of this range on its eastern base, but the intervening region is unknown to me, and is, I believe, incompletely botanically explored.

In the tables appended, I have made a rough division into two parts: westward and eastward, taking as my division a line approximately north and south, from the Trigonometrical Station on Pidurutalagala (8,292 ft.)—the highest point in Ceylon.

Obviously, such a north and south line is practically defective, as it would cross valleys that have equally eastern and western aspects, that would clearly produce confusing results if strictly followed; hence it must be understood that my western and eastern limits are separated more or less roughly, so as to give, as far as possible, a distinction between the general plant distribution on both sides, or aspects, of the Island.

Owing to the imperfection of the data at my disposal, I considered that the totals arrived at in my tables can only be accepted with reserve, so that all attempts at comparison between the number of plants recorded from the west of the Island, as compared with those on the east, at any given elevation, may be modified at any time, upon more minute exploration being effected. These figures, therefore, must be regarded as tentative. It is hoped that a more complete examination will, in time, be made, in order to supply the deficiencies that now strike one as obvious, more especially as there is no reason to assume that so many forms recorded in the west, *cannot* occur in the east.

In the course of my analysis under orchids, certain special reference might be made to the striking absence of particular forms, but it is not necessary in a brief introduction to my subject, to dwell more particularly on these points, out of their regular sequence.

The obvious variation of rainfall in many parts of Ceylon naturally affects the vegetation; and perhaps, in proportion to its area, there are few places in the world where such wide changes of rainfall occur as in this Island.

It is possible, in a single day, to leave a spot in the morning where the annual rainfall averages 40 inches, and arrive at another, in the same day, where 350 inches of rain, or more, fall in a year. These conditions are important.

It may also be observed, that while this great variation of rainfall occurs, yet it is more on the westward half than on the eastward; and it naturally follows that the proportion of perennial streams are more numerous in the west than in the east. This condition sets up a larger soil denudation accordingly, but, on the other hand, the diminished rainfall increases the soil desiccation, due to sun-heat, and thereby produces conditions of, and on, vegetation, that cannot occur where the moisture is greater or more uniform.

Much importance, therefore, must be attached to rainfall distribution; in fact it may with certainty be said, that unless the moisture reaches a certain amount yearly, that certain forms will be found to occur. A typical example of this is to be found in *Schizostigma hirsutum*.

It also follows that a more evenly distributed rainfall reacts upon human operations, so that large areas of country that were once forest are now in permanent cultivation, whereas, in the localities where water is scarce, very much of the land that has been brought under a form of cultivation has been subjected to periods of abandonment, when once more the land reverted to a secondary growth, in which an entirely different struggle for existence followed the destruction of the primeval growth.

How far these operations dislocated then existing forms, it is impossible to say, but it is reasonable to assume that they did do so.

On the other hand, by cutting down much of the natural vegetation, the opportunity *may* have been given to certain struggling forms to find more space wherein to survive. But this, again must, in the nature of things, be speculation.

Without attempting to find the cause of our *Patana* lands, we are faced with the fact that they play an important part in the distribution of our flora. It is striking, that while these Patana lands absorb a very large extent of our mountain area (estimated at 1,000,000 acres), they do not produce a large number of endemic species of grasses, yet the grasses form our largest order.

The evil and destructive practice of burning these Patana lands may have much to do with the loss of many forms of plants, not confined to the *Gramineae* alone, but that is hardly sufficient to explain why so few species under this great order are endemic, as compared with other orders. It can hardly be contested that their seed dispersal is more difficult, or apparently is not.

The *Talawa* lands, or as they may be crudely described as Jungly Patanas, are also curiously deficient in endemic forms in proportion to their extent, but, on the other hand, Talawas are not common in regions of considerable rainfall. They may be said to belong to the dry region, extending from a little above sea-level to 1,200 feet, after which they assume more of the typical Patana form, and less of the " Park " character ; while the true Patana form of land is more common at high altitudes, the Horton Plains, for example.

In his masterly paper on the "Botany of the Ceylon Patanas," Pearson[2] supplies an important list of Patana plants, but it is striking that it does not record one single endemic genus, though it enumerates 43 endemic species.

This is the more remarkable when one notices the large number of endemic genera set out in the tables of distribution, as it is evident that the altitudinal range of our Patana lands fully comprehends those altitudes in which endemic genera can exist. The conditions of light are, however, very much different, to which must be added the adverse conditions of a matted surface (generally speaking), as contrasted with a free surface, or one shaded by other growth.

In an abstract given by Pearson of the total flora of the Patana lands, it is significant that, below 4,500 feet altitude, the *Gramineae* form the larger percentage, while above that level the *Compositae* are in excess. Further, it may be observed, that below 4,500 feet the *Leguminosae* are more numerous per cent., than at the higher altitude, yet

of leguminous species we have only a gross total of 12 endemics out of 64 genera and 207 species.

The action of wind is of great importance in considering the possibilities of dispersal of plants, and the difficulties plants have to accommodate themselves to conditions when wind is severe. Though Ceylon may not be regarded as a country where the winds are of exceptional violence, yet their force is sufficiently severe in many parts of the Island to affect the vegetation in a very marked manner. This is particularly so in those places above 4,000 feet altitude, and again on the coast on the south and west, where the forest is materially stunted by the wind; but where there is the combination of high wind and low rainfall, the effect on the vegetation is most marked.

A careful exploration of the forests north of the railway from Mannar to Medawachchiya, and south of the same line to the valley of the Kala Oya, is very convincing with regard to the effect on vegetation of wind; but within this area there are other conditions, which will receive consideration in their place.

Round Madugoda, where there is a combined condition of high wind in the south-west, and a mid-altitude, there are peculiar characteristics of growth in Patana areas, such as an abundance of Eugenias. The same condition applies to the Patana lands east of Belihuloya, from 2,000 feet to 4,000 feet altitude, where once more *Eugenia* and *Careya* are characteristic.

Where a high altitude is much affected by the monsoon, both with respect to rainfall as well as wind, it is noticeable that stems of trees become much shorter, crowns closer and much frayed, and leaves more coriaceous above. For example, at 5,000 feet, on the Gongalla range, I have found *Wormia triquetra* with leaves 3 inches and less in length, while at 1,000 feet they are often as much as 10 inches long, with poorer soil to grow in.

Correspondingly, at the summit of Pettiagalla (4,687 feet), where the exposed condition of the mountain to the S.W. monsoon is most extreme, the vegetation is only a few feet high, and difficult to walk through without tearing one's clothes to pieces. On the top of Dotagalla, where the wind is serious and the humidity is considerable, *Garcinia echinocarpa* appears more like a bush than a tree.

On the summit of the "Knuckles" (6,112 feet) facing eastward, the growth is dense, almost tunnel-like, so that light conditions for plants growing under this vegetation are most unfavourable.

The influence of Uleas cultivation is perhaps one of the greatest importance in the matter of destruction of species. It must however

be divided into two very distinct divisions, viz., *Dry Zone* Chenas, and *Wet Zone*.

As already known, the operation of "Chena Cultivation" consists of cutting down the forest or jungle before the rains, burning, and growing in a most primitive manner such crops as the people require for food. These are mostly grain crops. Enormous quantities of plants, large and small, are destroyed by this wasteful form of "culture;" the land is in no way conserved against denudation, and after the crop is taken it is simply abandoned, till such time as the so-called "cultivator" is pleased to cut down the secondary growth, to repeat the "cultivation" again. No form of agriculture could be more wasteful than this, or less excusable, but as this paper is not devoted to administrative questions, these deplorable methods need not further be discussed. In the wet zone, such for example as the Kukulu Korale, where chena cultivation has impoverished both land and man to a terrible extent, much of the secondary growth is marked by dense masses of *Gleichenia linearis*, with patches of *Hedyotis fruticosa*, *Wendlandia Notoniana*, *Aporosa latifolia*, and frequently *Phoenix*.

On the stream sides, in swamps, and in places where the chena fires have not done their worst, a little is left of the natural vegetation, the wet ground in particular, in which in the case of marshes, examples of the *Eriocaulonaceae*, and *Cyperaceae* are very abundant. *Nepenthes distillatoria*, Exacums, Torenias, and Burmannias, are also very characteristic of moist patches of soil in the particular locality mentioned. In other wet-zone chena lands of the western slopes at low altitudes, *Ochlandra stridula* practically excludes other vegetation, growing as it does in large and dense masses.

In the dry-zone chenas, the secondary growth is naturally very much retarded by the drying of the soil, though, broadly speaking, the soil is much richer, and owing to the greater flatness of the ground, there is not so much soil denudation, while it has the additional advantages of holding up silt from higher levels. Yet, with all these advantages, the secondary growth is excessively poor in species, and poor in size of growth. Masses of thorny bush practically describes the succeeding growth in the dry country. In many places an abundance of *Malvaceae* might be regarded as almost typical, while in others there may be a preponderating amount of *Carissa* an uncomfortable abundance of *Randia* or *Flueggea*; but nowhere in these desolated areas do we find a restoration of species to their normal numbers, even though individuals will be found in great abundance.

It can hardly be said that the secondary growth in these chena lands succeeds in producing full grown trees, even after they have es-

caped a second or third rotation of cultivation ; thus it may be safely asserted that the distinction between primeval forest (*Mukalana*) and the very best secondary growth is always marked and pronounced. We may then expect to find the inaccessible, or practically inaccessible, forests to be richest in species, thus materially adding to the complexity of the problem of distribution.

Another aspect of the situation is the introduction of species by man, these having in the course of time established themselves, and entered into competition with the natural flora. No better examples could be found than in *Ageratum conyzoides*, *Lantana*, and the still more recent of introduction, *Mikania*, not to mention many others that are well-known but less apparent. In the case of *Mikania scandens*, we have a pestilential weed, that by completely growing over forest trees has, in many parts of the wet-zone, completely destroyed the natural vegetation within a few years. In the valley of the Weganga, *Mikania* was unknown in 1890 : to-day it is to be found covering large areas of ground and stamping out the native flora.

Ageratum conyzoides is to-day an abundant weed, even in the dry-zone, while *Lantana*, which was introduced about 100 years ago, is now so completely in possession, as to justify the expression, "Lantana land," being used in many of our districts.

This successful establishing of a foreign species has undoubtedly been the result of the stranger not having the same enemies to contend against in the land of its accidental adoption, as it had in its natural home. It therefore succeeded enormously, when it was relieved of this competition, with the result that it established itself at the expense of its new and unprepared neighbours. Such successes as these must react on indigenous and non-idigenous flora equally, and it can only be a matter of time for the new-comer to find its own conditions of life restricted, but that interval may involve the extermination of many endemics that otherwise might have become established.

How long it may take to exterminate any one particular species, endemic or otherwise, is probably unknown, but it certainly can be demonstrated that such has happened within a comparatively short time, notwithstanding favourable soil, rainfall, and light variations. I can, within my own recollection, instance an example of a land that was cleared and abandoned, becoming, at first, a sort of pasture for cattle, who fed freely on fruits of *Psidium Guajava*. The cattle, in their droppings, deposited the seeds, which grew with such abundance that when I revisited this spot a few years ago, it practically formed a sheet of guava trees. Yet this plant is a native of Tropical America.

A very remarkable *Calophyllum* is to be found growing in wild profusion below a cave near the summit of Degalhella, on the confines of the Eastern Province. The cave was, in ancient times, in occupation by priests. The fruit of this species of *Calopyllum* is rich in a green oil that is a specific for itch, which is a common disease in the dry country, and it is alleged that the priests employed this particular oil as a remedy, which accounted for its introduction.

In the same manner *Mesua ferrea* is found in regular forests of that plant, in several places in the Island. On the summit of " Westminster Abbey" ("Govinda Hella") that can only be reached by placing ladders into various crevices, the common pineapple grows on one particular portion of the rock in profuse abundance. It is only a short distance from the ruins of a palace that once stood there, among the remnants of which I found *Notonia grandiflora*, that could hardly have got there by accident.

While admitting the difficulty of accounting for the distribution at certain altitudes of certain specific endemics, the evidence I think is strong, that the action of man has played an unconscious, but important, part in separating forms that otherwise would appear to be more common, and by this process of separating or isolating patches of natural jungle or forest, a new form of inter-competition has been set up, owing to the restriction of the areas involved.

The above brief sketch is, at best, only an outline that is deficient in details. The tables that follow show against each endemic species its distribution altitudinally, while a brief analysis is also given bearing more directly on the orders involved, and their method of growth, from the dispersal stand-point.

Without more complete knowledge of the individual means of transmission, it is but speculative to account for the distribution beyond possible means, or obviously possible ones, and therefore I feel it would be idle to attempt to lay down any law on the subject. Equally, as our data leaves much room for amplification, I see no advantage in showing any particular ratio of proportion between our total flora and that at any particular altitude, or where a family is specially well represented.

The order *Ranunculaceae* is represented in Ceylon by 5 genera, and 7 species, of which one is endemic. The seeds are apparently not specially sought for by any particular animals. Our one endemic is found in marshy land at high altitudes, in Patana lands. The seed is possibly water-carried.

The *Dilleniaceae* are represented in Ceylon by 6 genera (1 confined to the Island), 15 species, varieties excluded, of which 12 are endemic. On reference to the table illustrating altitudinal distribution, it will be

observed that the genus *Acrotrema* is richest in endemics, and that these are best represented at 2,000 feet on our westward slopes. I think it is probable that some occur on the eastern slopes, but I have no data.

Under *A. uniflorum*, Trimen records no less than nine varieties, which I have not recorded, but the number of endemic species alone is striking. The fruits do not appear to be specially attractive, or to have special means of dispersal. They—the endemic species as a whole—usually select steep, shady, mossy banks for their growth, *lyratum* alone preferring large damp rocks to grow upon. It appears possible that caterpillars may convey the seed, internally or entangled on their hairy bodies. Where they occur, the plants of this genus might be said to be gregarious.

In *Schumacheria* (the genus confined to Ceylon) we find the same gregarious habit in the two low wet-country species, *S. castanaefolia*. and *S. angustifolia*, while the hill species, *S. alnifolia*, is almost solitary. The seed dispersal may be by water, and spread naturally from centres.

Wormia triquetra has a fleshy fruit, and is probably animal-carried. Its absence in the east is remarkable in a plant with such a range.

Dillenia retusa. Fruits, animal-carried. This plant is also economic, and may be artificially spread.

The large order *Anonaceae* is represented in Ceylon by 13 genera, and 39 species, of which no less than 21 are endemic. Of these endemics, only a very few are found in the hills, and comparatively only a limited number are in the eastern section of the country. The fruits may, without elaboration, be classed as fleshy, while most of them are distinctively attractively coloured, so that animal-transportation is most likely.

Our specially hill form, *Bocagea coriacea*, is not attractively fruited, but as it is abundant in steep land, its dispersal by gravitation is possible, as its presence on *flat* land is not so great as on steep. The scarcity of *Alphonsea sclerocarpa*, and its restriction to the eastern aspect of the country, is significant. Its fruits are ovoid and hard.

It will be observed that though the well-represented order *Menispermaceae*, with it's 10 genera, has advantages in being able to climb over other plants, yet it supplies no endemic species, while two other climbing orders, or practically climbing orders, the *Asclepiadaceae* and *Convolvulaceae* produce 7 and 3 endemic species, in 4 and 3 genera respectively. As all these three orders have this advantage of growing over the tops of their supporters, and the *Menispermaceae* in particular have attractive fruits, it is the more noticeable that Ceylon has no endemic example.

It is also striking that the *Capparideae*, with their abundant representation in genera and species, have no endemic forms here.

The *Violaceae* are comparatively poorly represented. We have only 3 genera, and 8 species, yet we have 3 endemics, with dry fruits, belonging to a low altitude.

The *Bixaceae* have 6 genera and 11 species, of which 7 are endemic. One of the genera is monotypic. The table shows that order is fairly confined to below 3,000 feet, with one exception, while the fruits are all beast-attractive. *Hydnocarpus venenata* is water-carried, and abundant in both aspects.

The *Pittosporaceae* is here represented only by a single genus and 2 species, one of which is endemic, and appears both in the eastern and western sections. Its red pulpy testa probably makes it bird-carried.

The *Polygalaceae* are made up of 3 genera, containing 11 species, of which in Ceylon, 2 are endemic and confined to the lower altitudes of the western aspect. The fruits are not attractive, but are possibly water-carried.

The *Caryophyllaceae* are well represented in Ceylon, there being 5 genera and 6 species, of which *Stellaria drymarioides* is peculiar to the country, but has only once been found here. This may be found to be an introduction. The order does not present any attractions to animals to secure their help in dispersal of seed.

The important order *Guttiferae*, composed of trees, is represented by 4 genera and 19 species, of which there are 11 endemics, each genus contributing. Most of the endemics belong to the low-country, the outstanding montane forms being *Garcinia echinocarpa*, and *Calophyllum Walkeri*. The fruits of both *Garcinia* and *Calophyllum* are animal-attractive, as well as economic, so that their distribution is simple. *Mesua Thwaitesii* is water-loving, but it is particularly noticeable that the distribution of this particular endemic is confined to stream-sides in places of high rainfall. It might be looked for in streams below the " Nitre cave " district, as so far it appears only to be recorded from the western half of Ceylon. *Kayea stylosa* I have found in very wet ground in the Pasdun Korale. The seeds are doubtless water-carried.

The *Ternstroemiaceae* in Ceylon form 4 genera, and 7 species, of which 4 are endemic, and all confined to the higher altitudes, one of which, *Gordonia speciosa*, has been but once recorded. The fruits do not appear to be animal-attractive. *Terntroemia emarginata* is water-loving, while the seeds of *Gordonia* may be, to some extent, wind-carried. *Adinandra lasiopetala* has fleshy fruit, that I suspect is eaten by the hill myna, much as I have seen this bird eating the fruits of *Myristica laurifolia*.

The large order of *Dipterocarpaceae* is very well represented in Ceylon, and, from the point of view of trees, is perhaps our most valuable family. It consists of 10 genera, and 48 species, of which no less than 47 are endemic. Of the genera, *Doona*, *Stemonoporus* and *Monoporandra* are peculiar to the Island.

More than a passing notice is deserved by this great family of trees, that present complex questions as to their local distribution. Most of the members have winged fruits, and many of them have a distinctly gregarious habit, while there are apparently none at our highest altitudes. Moreover, the order, as a whole, appears to be confined to the western section of the country ; the outstanding eastern form being *Vatica obscura*. *Dipterocarpus* is a conspicuously winged genus, and fruits are often carried by the wind to considerable distances. They are, however, much subject to insect attack, so that many are destroyed in this manner. All are gregarious within certain limits. *D. zeylanicus* occurs as one of the few Uvan Dipterocarps, but rapidly disappears after passing a little way beyond Park Estate, Lunugalla. *D. scabridus* I have obtained in one small cluster of trees in the Pasdun Korale, and it is recorded from Ratnapura.

Shorea is apparently a western-Ceylon genus. It's fruits are wind-carried, but the distribution is more or less confined to isolated patches, where numerous individuals cluster. *S. stipularis* appears to be patchily common in the wet Kukulu Korale, where I have found it in rocky ground on hill tops. *S. reticulata* I have doubtfully included. The same may be said of *S. Dyerii*, which, I *think*, occurs at Udugama.

Doona is a distinctly western form, of which one, *D. Gardneri* belongs to the hills. All are strongly winged, and all are gregarious, within limits. I have found, especially with *D. Gardneri*, that seedlings are frequently to be seen in masses, so that it would be impossible for more than a very limited number ever to reach maturity, so that the mortality must be exceedingly high.

Coupled with this circumstance, is the further fact, that during the monsoon numbers of immature fruits are torn off by the wind and scattered, from which it may be assumed that of the total volume of fruits produced in a year by a single tree possibly not one per cent. ever reach maturity. *D. zeylanica* appears to share the same disability as the last named. *D. congestiflora* is distinctly gregarious, and in places quite common, but it is certainly only so in isolated masses. *D. macrophylla* is another example of isolated gregariousness. I have found it in abundant masses in the Kukulu Korale, and again at Hewissa, and at Udugama, all places of high rainfall. Monkeys certainly eat the

fruits of *D. macrophylla* and *D. cordifolia*, but I think that transportation by their agency is exceedingly improbable.

Hopea affords one very large tree in *H. discolor*, which is locally gregarious in parts of Sabaragamuwa, and bears strong wings. *H. jucunda* is decidedly a water-loving plant, and probably the fruits are water-carried. The little variety, *modesta*, is in certain places distinctly gregarious, as I have found it so both in the Sabaragamuwa Province, and in the Pasdun Korale, but always in places of high rainfall. *H. cordifolia*, on the other hand, I have found close to streams in the south of Uva, and in the neighbourhood of the Wallawey river close to Uggalkaltota. It flowers at very distant intervals of time. The fruits are winged, but I think are water-carried.

Sunaptea scabriuscula is distinctly a rare species. It is winged, but I have nowhere found it other than confined to small groups of trees.

Vatica obscura I have found in isolated gregarious masses generally near streams in the south-eastern part of Ceylon. The farthest western limit to which I have traced it was in a dry stream on the south of "Westminster Abbey." On the other hand, Tumpalancholai takes its name from this plant, which in Tamil is "Tumpali"—as obvious corruption of the Sinhalese word Dumalla, meaning resin, from the highly resinous nature of the plant.

Balanocarpus, an Indian genus, is in Ceylon very restricted. Our only species, *B. zeylanicus*, if it is to be included, appears to be confined to the top of the isolated Doluwakanda mountain, where I found it growing gregariously and abundant.

It may be worth considering, that on the top of this mountain there are the remains of an old palace and a tank, so that this strangely isolated plant may have been introduced. It's fruits do not suggest animal-transportation.

Vateria acuminata is distinctly water-loving, and has large fruits easily carried by water. The fruits are moreover eaten. I have failed to find it in the eastern half of the Island, but I suspect that it has been overlooked.

The large genus *Stemonoporus* with its 15 endemic species which are all spherical fruited, and have no special attractive features for animal-transportation. Of these, *S. Wightii* is water-loving, and the fruits are, as I have found, water-carried. On the other hand, the distribution is restricted. *S. Gardneri* is a hill species, found in steep land, where it is sub-gregarious. *S. acuminatus* is one of our rare forms, and apparently riverine. *S. affinis* is, as far as I have found it, sub-gregarious, and devoted to very steep land at high levels. The fruit I have

frequently found at long distances from the parent trees, having rolled down. *S. caniculatus* has likewise globular fruits, but is not found in the same local abundance as the last. *S. petiolaris* I have found in the Rakwana hills, west of Gongalla, in apparently very wet forest. It is confined, as far as I know, to gregarious patches.

Passing to those of this genus with which I am more familiar, I may perhaps be excused for dealing in some detail with two discovered by myself. Of these, *S. Lewisianus* so far has been found only in Sabaragamuwa, and in each case on the very summit of rocky hill tops, and restricted to a very small area. Some of the trees I found were of immense size. The fruits are very small, very much grub-eaten, and distinctly unattractive. The plants grew gregariously, and suddenly at a comparatively short distance appeared to be totally absent. The rainfall of the two places where I found these handsome trees must have been close on 200 inches per annum, and the place seriously wind-blown. The two places were wide apart, the first being about 2 miles from Pelmadulla and above Bambarabotuwa, and the second in Eratna, on the edge of the Peak Wilderness.

S. revolutus I found in a precipitous mass of rocky land overlooking Deepdene Estate, in the Kukulu Korale. Here the plants were subgregarious, but confined to a very small area. The fruits are globular, but not abundant on any of the parent trees. Rainfall, high.

Monoporandra cordifolia occurs in the wet forests of the Adam's Peak range. I have found it in very steep lands only, and have traced it eastward of Meriakotta Kanda in the forests overlooking Waleboda, but nowhere in large numbers. The fruits are globular, but not eaten by any animals as far as I am aware.

Ancistrocladus Vahlii is a low-level form, capable of climbing to a limited extent, and possess winged fruits. It is, however, fond of moist ground. Apparently it is a low-level western form, and certainly not rare.

The order, as a whole, presents many difficulties in the way of explaining its erratic local distribution. It appears to be distinctly Malayan, extending as it does to New Guinea, from which country, according to Brandis,[1] 8 species were recorded up to 1894. Westwards, the order is represented in the Seychelles by *Vateria seychellarum*. It is curious that, while the order is so conspicuously in an ascending scale as we proceed eastward, the local representatives in Ceylon are confined to our westward side. This peculiarity also applies, as the table indicates, to the greater part of our endemic flora, and presents a feature that cannot be entirely explained by rainfall alone, more especially where, as in the case of this order in particular, we are dealing with gregarious forms.

A careful botanical survey of Moneragalla may disclose a considerable variation in distribution of the endemics on this isolated mass of mountains, more especially with respect to Dipterocarps, as these will be found its southern-most forms to end here.

The *Malvaceae* form a large order in Ceylon, having 12 genera, and 36 species, of which 2 are endemic. *Julostylis* is monotypic, while the small Indian genus, *Dicellostyles*, has our only other endemic representative of the order in *D. axillaris*. *J. angustifolia* has a densely stellate fruit, that does not appear to be animal spread, while the "very rare" *D. axillaris* has a pilose hairy fruit. As suggested elsewhere, the order is abundantly represented in areas where the growth is secondary, the best exception being *Cullenia*, which is a purely forest tree, though not endemic.

The order *Sterculiaceae* is represented in Ceylon by 7 genera and 12 species, of which only one, *Sterculia Thwaitesii*, is endemic. The genus to which this endemic belongs possesses characteristically follicular fruits, generally woody and thick, but the seeds are possibly animal-carried. The brilliant follicles are likely to be attractive, as inviting attention to seeds.

The *Tiliaceae* cover 6 genera, one of which is monotypic, and 30 species, with a total of 7 endemics. Excepting the monotypic eastern form, *Pityranthe verrucosa*, most of our endemics extend up into the hills, but the majority are western. The fruits in *Grewia diplocarpa* do not appear to be specially adapted for transportation, while in *Triumfetta glabra* we find coloured and hooked spines, abundantly covering the pericarp. *Elaeocarpus* is provided with a fleshy epicarp, and is sought after by birds, monkeys, and squirrels, by which agencies species are carried, notwithstanding the rarity of some of the individual endemics themselves. I am doubtful if the eastern record of this genus has been exhausted.

The *Linaceae* is a small order in Ceylon, represented by 3 genera, and 7 species, of which 3 are endemic. *Hugonia ferruginea* appears to be a western form, but I have no knowledge of it. *Erythroxylon acuminatum* (=lucidum, Trim. *Flor.*, Part I., p. 191) is possibly planted, as it is much valued for its medicinal qualities. It is also bird-carried.

E. obtusifolium, which occurs abundantly in the Eastern Province, has a bright scarlet fruit that renders it conspicuous to fruit-eating birds, and possibly bats.

The *Geraniaceae* are represented by 5 genera, and 29 species, of which 18 are endemic. Of these, the transportation of *Biophytum nervifolium* is probably by a creeping process, or if I may use the word, geometridally, as I have found no animals feeding on the plant, other

than insects. It adopts the flat country, and dry areas. *B. nudum*, on the other hand, is common by streams at high altitudes, suggesting water-transportation. *B. proliferum* is gregarious in patches in open spots in the hill country; I cannot offer any explanation of its occurrence.

The genus *Impatiens* has no less than 18 endemic species, more or less associated with wet ground or streams. Seeds may become embedded in mud, and so be carried by such birds as wagtails, but definite data is wanted to support this novel means of seed transit. Many of the larger forms grow by stream sides, and as the capsules open with a spring, seed can be flung off to an appreciable distance. I am not satisfied with the evidence, or I should say *want* of evidence, as to seed dispersal, especially as in the case of *I. repens* we find a type that may be found abundantly growing on wet rocks in one place, and for 10 miles it does not occur again, when it may appear in an isolated spot completely surrounded by high forest. I have found it on a wet slab rock near Yatiyantota at 500 feet altitude, and again on a damp rock at 3,000 feet altitude beyond Lunugala. I do not see a satisfactory means for explaining its appearance in the latter case, where it is isolated. *I. elongata* I found practically on the summit of the precipice-surrounded "Kunadiyaparawitta" mountain. The next nearest place to this point where it has been collected is Adam's Peak. It cannot be supposed that it was bird-carried, as it does not grow in mud, nor are the fruits attractive. The eastern forms are conspicuously badly represented.

The *Rutaceae* in Ceylon are very well represented. We have 13 genera, and 23 species, of which only 2 are endemic, and both of these are recorded only from the eastern section. Both *Glycosmis* and *Murraya*, from which our endemics arise, may be classed as berry-producing, and thereby possibly animal-carried. It is striking, however, that, so widely represented an order as the *Rutaceae* is, with its altitudinally widespreading numerous members, endemics are so few. It is difficult to suppose that at one time there were more owing to "foreign competition," as such a conclusion is not borne out by comparison with other orders that are well represented, but are endemically deficient.

The small order of *Ochnaceae* is represented by 2 genera, and 4 species, one of which is endemic. This is the "very rare" *Ochna rufescens*, collected in 1855, and apparently not since found. More material appears to be wanted to decide if this is really a distinct species.

The *Burseraceae* are represented in Ceylon by 3 genera, and 5 species, of which 2, under the genus *Canarium*, are endemic. Of these latter, *C. brunneum* is rather distinct in its selection of soil, as compared with *C. zeylanicum*. *C. brunneum* may usually be looked for on deep rich

soils, in valleys not far from water; *C. zeylanicum*, on the other hand, is most frequently to be found in shallow soil, often on mere crusts of earth overlying slab rock, or on ridges. In both species the fruits are large, conspicuous, and stony. I have seen mynas eating the latter, but it is difficult to understand how such a large seed could be swallowed. Monkeys eat the fleshy exterior, while man appreciates the "nut" of the latter species.

The *Meliaceae* are largely represented in Ceylon. There are 12 genera, and 14 species, of which 4 are endemic. Of the genera, *Pseudocarapa* is monotypic.

It is, however, curious that out of 12 genera only two have as many as two species, leaving all the remainder with but one each. *Munronia pumila* appears to be confined to the dry country, in the east. I have traced it in the valley of the Kumbukkan river, and also west of "Westminster Abbey." I suspect that, owing to its popularity for medicinal purposes, it has been exterminated. It's dispersal is probably geomitridal. *Aglaia apiocarpa* has smooth, orange-coloured berries, attractive to birds. *Pseudocarapa Championi*, having fleshy arils round the seeds, is most likely bird-carried. The trees of this species are lofty, and it is strictly a forest species. *Walsura Gardneri* has ovoid, dull orange fruits, with attractive arils, and is probably monkey-eaten. The southern limit of distribution of this little tree should be looked for, especially at Moneragalla.

The *Olacineae* is another moderately large order, with few species. It is represented in Ceylon by 10 genera, and 13 species, of which only 2 are endemic. *Olax* presents 3 species in Ceylon, and 7 in India. The Ceylon endemic example *O. zeylanica* is, however, a small tree, with very bright scarlet, attractive fruits. It occurs both in the wet and dry-zones, but more abundantly in the former; it is bird-eaten. *Apodytes Gardneriana* is fairly common; it's small fruits are possibly bird-eaten.

The *Celastraceae* are represented in Ceylon by 11 genera, and 19 species, of which 6 are endemic. Of the endemics, *Euonymus* alone contributes 3. These are *E. revolutus*, *E. Thwaitesii*, and *E. Walkerii*. Their method of seed dispersal is not clear, nor can any of them be regarded as common. The coloured inner coat of the capsule conspicuous in *E. Walkerii*, may be bird-attractive. I have found a nest in a tree of this species, but I am unable to say if I have found evidence of the seeds being bird-eaten.

Microtropis Wallichiana appears to be bird-eaten, and is a widely distributed little tree.

Gymnosporia fruticosa appears to have been found only once, and that by the side of a river.

Kurrimia zeylanica is bird-eaten, especially by mynas. Its eastern distribution is probably much larger than my tables show.

The *Rhamnaceae* in Ceylon afford 7 genera, and 12 species, of which 2 are endemic. These are *Zizyphus Napeca*, and *Rhamnus Arnottianus*. The former of these two, if identical with the plant I obtained at Hiripitiya in the North-western Province, is certainly bird-eaten, Barbets being fond of it. *R. Arnottianus* is certainly bird-carried, as its fruits are attractive.

The small order of *Ampelideae* has in Ceylon only 2 genera, but 20 species, of which 5 are endemic. There appears to be no reason to suppose that the fruits of any of these endemics are not animal-eaten, so that their transportation can be so accounted for, but it is not so evident why the greater number of species should be more common at the low levels than at high. This may be a matter of rainfall, as there is certainly a tendency for the order to be better represented in the dry-zone.

The *Sapindaceae* are represented by 11 genera, and 19 species, of which 5 are endemic. One of the genera supplies the monotypic *Gleniea*. Of the endemics, the genus *Allophylus* has one, out of 3 species. This is *A. hispidus*, which, according to Trimen, is rare. The fruits of this genus are coloured, and bird-eaten. *Gleniea zeylanica* is exceedingly common in the dry country, especially in the east and south-east. It's fruits are eaten by birds, and Orioles often select its branches for nesting. *Sapindus erectus* is yellow-fruited, and much bird-eaten. *S. Thwaitesii* I have not seen, but probably the fruits are bird-carried.

The order *Anacardiaceae* is made up of 7 genera, and 19 species in Ceylon, of which the high proportion of 15 are endemic. Of these no less than 13 belong to the genus *Semecarpus*, completely absorbing the whole of that genus. Taken in their order, *Mangifera zeylanica* is our only indigenous mango; the fruits are eaten by monkeys, as well as by man. I have observed a considerable variation in the size and colour of the fruit of this widely-spread forest tree, having obtained both yellow and purple fruits. In the dry zone, the wild mango is not so abundant as in the damp forests of the west, but, as its timber is made use of for the manufacture of tea boxes, it is not unlikely to be wiped out in accessible localities. In *Semecarpus*, the fruits are all more or less possessed of a fleshy (and in some cases attractively coloured) receptacle. This probably helps in their transportation, though it is remarkable that the poisonous acid contained does not appear to react against diffusion. Our genus appears to be more confined to the wet country than the dry. Some are found commonly by streams and marshes. *Campnosperma zeylanicum* is practically a wet-country tree,

growing gregariously. It's fruits are small, pulpy, and pigeon-eaten. It appears to thrive in very poor soil, and is a "surface feeder." Its great popularity for packing-case manufacture may probably exterminate it, as it is not a widely-distributed tree.

The *Connaraceae* afford 3 genera, and 4 species, of which 2 are endemic. These are *Connarus Championii*, and *Ellipanthus Thwaitesii*, both of which have conspicuous arils and consequently are attractive to animals.

The great order of *Leguminosae* is, in Ceylon, represented by 64 genera, and 207 species, of which only so few as 12 are endemic. *Pericopsis* alone is monotypic. While most of the genera have many species, yet the endemics are curiously few, as for example, *Crotalaria* has 23 species, but only 2 are endemic ; *Desmodium* has 21, and 2 endemics ; *Indigofera* has 16 species, but no endemics ; *Cassia* 12, and no endemics ; and equally no endemics among the 9 Acacias. It may be remarked, however, that the majority of the species of this large order are deficient in fruits that are eaten by animals, but this, while it may restrict distribution, does not apparently account for the comparative scarcity of endemics. Assuming that our collections are tolerably representative of distribution, it will be seen that our endemics are not specially confined to any particular altitude and in that way they agree with the general spread of the non-endemic forms. Our monotypic *Pericopsis* is certainly a wet-zone plant, and confined to low altitudes, but numbers of non-endemic leguminous plants are also abundant in the lower wet-zone. Broadly speaking, this order presents infinite difficulty in accounting for the means of dispersal, while the abundance of individuals makes it the more obscure how this distribution is to be accounted for.

A comparison between this large order and the *Rubiaceae* discloses some interesting contrasts, as follows :—

Order	Total Genera	Mono-typic	Species		Total Species
			Non-endemic	Endemic	
Leguminosae	64	1	195	12	207
Rubiaceae	47	4	67	71	138

It will be here observed, that while the fruits of the *Leguminosae* may be broadly described as non-attractive, those of the *Rubiaceae* are mostly fleshy, or likely to be freely sought after. It may be possible to account for the excess of the rubiaceous endemics on the ground that more individual plants are planted by this method of dispersal than in the case of the *Leguminosae* ; and carrying the comparison further to

the *Euphorbiaceae*, we find some confirmation, as the following figures tend to show :—

Order	Total Genera	Monotypic	Non-endemic Species	Endemic Species	Total Species
Euphorbiaceae	43	0	85	45	130

It will at once be observed that no monotypic genus appears, but, on the other hand, the endemic species are very fully represented, especially as the attractive-fruited forms are, as in the *Leguminosae*, proportionately fewer. It is suggested that while an abundance of seedlings are massed together, the struggle for existence must obviously be greater, thus tending towards development of specially varied characters to secure the preservation of the race. This speciality, may, in repeated races, be so far developed as to constitute a specific difference so marked as to constitute a distinct species, till in time it becomes, in itself, a definite product of congestion.

Against this theory, however, is the fact that *Strobilanthes* is not a fleshy-fruited genus, yet we have 25 endemics. On the other hand, at least some of the *Strobilanthes* are bird-eaten.

Returning to the *Leguminosae* and their local endemic distribution, it will be observed that four genera carry two endemics apiece, and four only one each. The most characteristically hill form is *Sophora zeylanica*, and it may be noted that the seeds are " bright dark red." *Pericopsis Mooniana*, a magnificent wet-zone monotypic plant, runs very considerable risk of extermination. It is in great demand for furniture, and is one of the finest and most durable of our woods, and if its exploitation is not closely controlled, or its artificial propagation extended, it will soon share the fate of the Calamander.

The *Rosaceae*, in Ceylon, are represented by 7 genera, and 12 species, of which 3 are endemic. These latter are *Pygeum*, *Poterium*, and *Agrimonia*, of which the first is a tree, fairly common in the low wet-zone, and the last two are herbs. The last, *A. zeylanica*, is to be found in open grassy land, its method of fruit dispersal is not known.

The *Haloragaceae* is another small order. It is represented by 3 genera, and 4 species, of which the one endemic, *Serpicula zeylanica* occurs at a high altitude. The fruits of the latter are minute, and their method of transportation is unknown. Its presence on the top of Adam's Peak, and on the opposite mountain, Kunadiyaparawitta, is curious.

The *Rhizophoraceae* family, in Ceylon, is made up of 6 genera, and 10 species, of which 2 are endemic.

With the exception of *Anisophyllea*, all our local members of this order are swamp, or damp-ground, loving species, of which *Rhizophora* ("Mangrove") is a brackish-water example. Of the endemics, *Carallia calycina* is a large tree, having small red fruits that are probably eaten by pigeons; it is not plentiful. *Anisophyllea zeylanica*, on the other hand, is a common endemic, chiefly found in the wet-zone; I am unacquainted with the manner of its fruit dispersal. I am not satisfied with its eastern distribution, shown in my tables, as I expect this common plant will be found to occur in the Nitre Cave Valley, and near the foot of the eastern flank of the Rangalla hills.

The *Combretaceae*, in Ceylon, are represented by 5 genera, and 11 species, of which one only is endemic. This is *Terminalia parviflora*, a fairly well-distributed forest tree in the west. I have doubtfully included it in my eastern distribution, as I remember to have seen it in the east, though unfortunately I did not record the locality. The fruits of this species are bird-attractive.

The *Myrtaceae* form, in Ceylon, 4 genera, and 49 species, of which 30 are endemic; and of these, no less than 29 belong to the genus *Eugenia* alone. The whole order has attractive fruits, especially among the Eugenias, which are readily eaten by birds. My tables will show that these endemics are widely distributed altitudinally, even though the eastern section shows so few. I have duly recorded the "rarity" of the individuals, but I think that the fact that we have a characteristically fleshy-fruited, many-seeded genus here typically illustrated, it, to some extent, supports the theory I have attempted to show. In the case of the last endemic in this order, *Barringtonia zeylanica*, we have a water-loving species, with fruits that are easily water-carried, though not so definitely as in the non-endemics, *B. acutangula*, or *B. racemosa*.

The *Melastomaceae* form a large order from the point of view of species and endemics. It has 6 genera, and 52 species, of which 36 are endemic, only two genera being *un*represented endemically.

Osbeckia has 5 endemics out of 9 species, *Sonerila* 8 out of 12; *Medinilla* 2, or the entire local genus; and *Memecylon* 21 out of 27.

Of the Osbeckias, the majority of our endemic forms are montane. It is unfortunate that our data, as regards the eastern distribution, are so bare, as it can hardly be supposed that none occur there. The capsular fruit is not, as far as I am aware, ever bird-eaten, while the seeds, which are very abundant, may possibly be water-carried, but at present I am ignorant of any special method of dispersal, other than geomitridal, for their transportation. It is possible that ground-feeding birds, such as jungle fowl, spur fowl, and bronze-wing pigeon, may eat the fruits of Osbeckias; but no cases that I am aware of have been proved of this.

In *Sonerila* we have well distributed examples. The problem of dispersal is perhaps more obscure than the last, owing to the singular situations where the plants are found, such as steep banks, rock crevices, mossy decayed logs, and the like. The seeds are always numerous and minute, but, as far as I am aware, are not wind-carried. I have found small caterpillars in the same places as Sonerilas and plentiful, but I have found no example of their feeding on these plants.

Medinilla fuchsioides is, I am certain, bird-carried. I have observed *Diceum* hunting along its branches for fruits, much in the same way as it explores *Loranthus*. *M. maculata* may be carried in the same way. The fruits of both these species are coloured and attractive.

The well-represented genus, *Memecylon*, is very well distributed altitudinally, though a number are, so far, described as "rare." The fruits of this genus are all berries, and more or less conspicuously coloured, and it may be noted that the "very rare" *M. phyllanthifolium* has very minute fruits. I think that owing to the abundant fruiting habit of the genus as a whole, and the attractive nature of the fruits to birds, a parallel to the abundance of endemics in the genus *Eugenia* is to be found here. In reality, if we take the ratio of 29 (total endemics) to 43 (total species) in *Eugenia*, and 21 (total endemics) in *Memecylon*, we get 31 as the proportionate number of species in the latter. In reality we have 27. Conversely, as 43 (total species in *Eugenia*) is to 29 (total endemics in *Eugenia*), so is 27 (total species in *Memecylon*) to 18, and we have actually 21. As we cannot be dealing with complete data, and the units themselves possess their own personal equation, the above results are not by any means unsatisfactory, even if they are not convincing.

The *Lythraceae* in Ceylon are expressed by 7 genera, and 15 species, of which one is endemic. This is *Axinandra zeylanica*, a curiously isolated form, that occurs in the wet country up to 2,000 feet.

The *Samydaceae* are made up of 3 genera, and 5 species, of which 2 are endemic, viz., *Casearia coriacea*, and *Osmelia Gardneri*. Both have coloured fruits.

The *Cucurbitaceae* family is very well represented in Ceylon as regards numbers, but badly so with endemics. There are 17 genera, and 26 species, 3 of which latter are peculiar to the country. Of these, *Trichosanthes integrifolia*, is a powerful climber, with brilliant crimson fruits that are eaten by monkeys. *Momordica denudata* is another climber with striking fruits, and the last, *Melothria zeylanica*, is a third scandent species, of a wide altitudinal distribution. It is rather remarkable, with so large a number of conspicuous fruited plants, that we have so few endemics, but this may be counter-balanced by the fact that so many are annuals, and the majority affect areas that are fre-

quently subjected to the process of "cultivation" known as chenaing. This process, added to an annual habit, may materially lessen congestion of individual forms.

The *Umbelliferae* family is made up, in Ceylon, of 7 genera, and 10 species, of which only two are endemic. It will be seen that none of the genera are large, 3 being the maximum number of species. The whole order is diminutive. Our two endemics, *Peucedanum zeylanicum* and *Heracleum zeylanicum*, belong to our higher altitudes and are unattractive as regards their fruits.

The *Araliaceae* are here represented by only 2 genera and 5 species, one of which, *Heptapleurum emarginatum*, is an epiphytic form, with small, but bird-attractive, fruits. The *non*-endemic *H. exaltatum* is a large tree rather characteristic of Uva, where it occurs in the small isolated patches of forest that are found in the Patana lands.

The *Cornaceae* is another small order, having in Ceylon 2 genera, each of 2 species, with one endemic in each. These are the climbing shrub *Alangium glandulosum* and the tree *Mastixia tetrandra*, of which last, a variety (?) is common in the wet forests in the west from 1,000 to 6,000 feet altitude. I am unacquainted with the mode of dispersal in both these.

The very large order of *Rubiaceae* is represented in Ceylon by 47 genera, and 138 species, of which so many as 71 are endemic. Of the genera, 4 belong to the Island. The order has some very large tree forms, as well as minute, shade-loving, dingy plants; some devoted to the wet-zone, others thriving in the dry, under the driest conditions.

The altitudinal distribution is very evenly shown, though I have again to deplore the paucity of data as regards eastern figures, where I am certain much revision is necessary. The fruits in this order may be classed as bird-attractive, and in that way most probably secure wide distribution, except where herbaceous forms are concerned. Dispersal by water is also quite possible, as in *Schizostigma*, which is an essentially wet country plant, growing in places reeking with active moisture. The very remarkable monotypic *Leucocodon reticulatum*, with its epiphytic habit, and fruits immersed in natural cups of water, presents a curious problem to account for its presence, or its dispersal, as it is unlike any other member of the order.

Scyphostachys is another genus peculiar to the Island, that appears to have affinity with *Coffea*, and has, like that important genus, attractive fruits. The monotypic *Nargedia* appears to be very rare; I am unacquainted with its habits or fruiting.

Comparing the proportion of endemics in the *Rubiaceae*, with that in other large, endemically well-represented orders, it will be seen that

it is surpassed in the orchids, and that fact may be taken as destructive to the theory I have advanced on the fleshy fruit basis ; but I submit that, in the *Orchidaceae*, we have a family in which the seeds are not only extraordinarily abundant, but extraordinarily small, and are therefore wind-carried. This subject will be found more fully dealt with further on.

In *Dipsacaceae*, we have a solitary genus, and only one species, which is endemic. Its fruits are dry, and our form is montane.

The great order of *Compositae* is very well represented in Ceylon by 36 genera, and 78 species, of which 19 are endemic. It will be observed that the average number of species per genus is only about 2.2. The largest genus is *Vernonia*, with 13 species, out of which 9 are endemic, while, on the other hand, we have no indigenous genera. The whole order has the characteristic of abundant seed, and these wind-carried. As regards our endemic *Compositae*, as might be expected, more are to be found in the hill country than in the plains. Of the non-endemic species, of which we have 59, it may be observed that get the following —

From	sea-level	to	1,000	ft.	.. ..	15
,,	1,000	to	2,000	ft.	.. ..	2
..	1,000	to	3,000	,,	.. ..	2
..	1,000	to	4,000	,,	.. ..	6
..	1,000	to	5,000	,,	.. ..	2
,,	1,000	to	6,000	,,	.. ..	8
,,	1,000	to	7,000	,, & over	.. ..	4
..	2,000	to	3,000	,,	.. ..	1
..	2,000	to	4,000	,,	.. ..	1
,,	2,000	to	5,000	,,	.. ..	0
,,	2,000	to	6,000	,,	.. ..	0
..	2,000	to	7,000	,,	.. ..	0
,,	3,000	to	4,000	,,	.. ..	1
,,	3,000	to	5,000	,,	.. ..	0
,,	3 000	to	6,000	,,	.. ..	1
,,	3,000	to	7,000	,, & over	..	2
..	4,000	to	5,000	,,	.. ..	0
,,	4,000	to	6,000	,,	.. ..	1
,,	4,000	to	7,000	,, & over	..	8
,,	5,000	to	6,000	,,	.. ..	0
,,	5,000	to	7,000	,, & over	..	5
,,	6,000	to	7,000	,,	.. ..	0

(These figures are arranged in these groups, so as to shew individual ranges, without repeating the altitude against the individual continually). Taking all below 4,000 feet, *i.e.* 1,000 up to 4,000 feet, we get 28 non-endemic species, and above that level we have 31. The endemics, on the other hand, show more forms above the 4,000 feet limit than below that altitude.

Of the *Myrsineae*, Ceylon has 5 genera, and 14 species, of which 3 are endemic and confined to the genus *Ardisia*, which is our largest genus in this order. The Ardisias all have berries, more or less attractive, and are chiefly distributed in the wet-zone.

The *Sapotaceae* order is one of trees in this Island, and is made up of 6 genera, and 17 species, of which 11 are endemic, spread over two genera. It is probable that further material may be obtained to lead to *Isonandra* being found to have endemic species among those now classed as varieties of *I. lanceolata* by Trimen. These are to be sought for in the wet forests of the Singha Raja, and in the " Peak Wilderness." *Bassia neriifolia* is a gregarious, water-loving endemic, abundant by river-sides in the lower parts of the wet-zone, extending, in the case of the Walawey River, up to nearly 2,000 feet. Like the rest of the genus, it has comparatively large fruits that are animal-attractive.

The whole seven species of *Palaquium* are indigenous, and all carry attractive fruits. *P. petiolare* attains a very large size, and is, in certain localities, to some extent gregarious. *P. rubiginosum* is distinctly so, at high altitudes. The fruits of this genus are strongly attractive, and are eaten by mynahs and jays. *P. grande* is a water-loving form.

Our important order *Ebenaceae*, though widely distributed, has only two genera, and 24 species, of which 11 are endemic, *Maba* having 3 out of 4, and *Diospyros*, 8 out of 20 species.

Of *Maba*, I have found *M. acuminata* plentiful in restricted areas in the wet-zone in the south. It's fruits are small, and possibly bird-eaten, but as I have found the plant more common by water, I suspect dispersal is effected by that means. I have not seen the fruits of the other two endemic Mabas, but the non-endemic and abundant *M. buxifolia* is certainly bird-eaten.

Diospyros attenuata, though not generally plentiful, is locally abundant. It may be said that the ranges of hills in the Pasdun Korale that culminate in the " Haycock " mountain possess more examples of this genus than any other part of Ceylon. The special reasons for this are not clear. These particular hills are steep, rocky, and in a very wet

part of the Island. That fruits of this genus are carried down by gravity, added to the movement of water, I have had evidence of both at Hewissa, and Borulugoda, and at the foot of Tittaweraluwakotta and Linigalla ; and at all these places I have found examples of different species of *Diospyros*. *D. Gardneri* is fairly common in, and beyond, the country just referred to, and often found near streams. *D. quaesita* I have only found in fruit in two places, viz., near Kokawitta in the Kukulu Korale, and at Karawita Kanda. This beautiful tree has suffered sadly, owing to the beauty of its handsome timber, so well-known under the name of "Calamander," and its present scarcity is probably due to its popularity, especially in Dutch times. The first examples of female flowers, as far as I know, were obtained in the Atakalan Korale, where I obtained them, and these were afterwards figured by Wright.[6] I may add, that for three years I offered a reward to anybody who would show me the fruits, *in situ*, of *D. quaesita*, but the offer failed to secure a single candidate. When I did find the tree in fruit (and this I may add was in an almost inaccessible mass of rock ground), I found that there was a most remarkably high percentage of mortality among seedlings that I raised from the seed, so that the question of dispersal is more than ever obscure. *D. hirsuta* and *D. Thwaitesii* are both found near streams, but only in the wet-zone, while *D. Mooni* I have found generally to affect the margins of swamps, or very wet ground. Unlike most of the non-endemic species of *Diospyros*, the endemics appear to be most abundant where the rainfall is very considerable, suggesting a water habit.

It will be noted that *D. Embryopteris* and *D. Toposia*, are both, to a marked extent, water-loving non-endemics, both being found by streams, though *D. Toposia* is not found in the eastern half of Ceylon. I have repeatedly found fruits of *D. Embryopteris* that had evidently been water-carried in the beds of non-perennial streams, but as the whole genus has light, ovoid, or spherical fruits, that are attractive, their transportation may not depend on water alone.

Our *Styraceae* form a single genus of 20 species (19 according to Trimen), of which 17 are endemic. The fruits are all bird-attractive. It is, therefore, the more remarkable that the eastern distribution is not better shown. The genus appears to be more confined to altitudes over 3,000 feet, than below.

Of the *Oleaceae* Ceylon shows 4 genera, and 12 species, of which one *Linociera purpurea*, a tree, is endemic. With the exception of this and

one other, the order is confined to climbers and small bushes. The fruits are not attractive, or appear not to be so.

The large order *Apocynaceae* is represented, in Ceylon, by 19 genera, and 25 species, of which 8 are endemic. Of these 19 genera, 15 have only one species in each ; 3 have two each ; while *Wrightia*, the largest with 4 species, supplies 3 out of the 8 endemics.

It may also be observed that the order, as represented in Ceylon, can only count 5 tree forms, 2 low plants, 9 that can be classed as bushes, and 9 that are creepers. Of the endemic forms, *Willughbeia zeylanica* is a very large creeper, that affords copious latex, and big pink fruits, that are devoured by monkeys. *Alyxia zeylanica* is a small plant, bearing brilliant scarlet poisonous fruits. *Holarrhena mitis* is one of the few trees of the order, with comose seeds ; *Wrightia flavido-rosea*, *W. zeylanica*, *W. angustifolia* are all of the bush class, and all have wind-carried seeds. *Baissea acuminata* is semi-climbing, and also wind-carried; and *Anodendron rhinosporum* may be also classed as a climber, and possesses seeds that are pre-eminently adapted to distant flight. The other members of the family have not such marked facilities for dispersal in all their units, and this may have its influence in a diminished number of species per genus, though it must be admitted that four of our endemic apocynaceous plants are the only Ceylon species in the genus in which such occurs.

The *Asclepiadaceae* is another of our large Ceylon orders. It is represented by 22 genera, and 39 species, of which 7 are endemic. It will be noted that of the genera, 17 have only one species in each, and that the largest number of endemics in any one genus is in the genus *Tylophora*, which has the greatest number of species. Moreover, it may be observed, that no examples of the order are trees, and that our representatives are composed of 3 bushes, 5 herbs, and 31 twiners. For dispersal, they have the advantage of possessing air-carried seeds, but with so many forms in which the climbing character is restricted by comparatively short stems, the chances of wide dispersal appear to be restricted. Moreover, many of the order occur in "Chena" lands, which, by being periodically burned, must by that circumstance cause the destruction of established, as well as young plants. As this order might be well compared with the *Compositae* in the matter of dispersal of its seed, both being wind-carried, I have compiled the following figures showing the percentage of non-endemics in both these orders, and at their respective zones of altitude :—

Altitude	Composites		Asclepiads	
	Number	%	Number	%
At 1,000 ft.	15	25.42	10	31.25
From 1,000 to 2,000 ft.	2	3.39	4	12.50
.. 1,000 to 3,000 ft	2	3.39	6	18.75
.. 1,000 to 4,000 ft.	6	10.17	4	12.50
.. 1,000 to 5,000 ft.	2	3.39	2	6.25
.. 1,000 to 6,000 ft.	8	13.56	—	—
,, 1,000 to 7,000 ft. & over	4	6.78	—	—
At 2,000 ft.	—	—	1	3.12
From 2,000 to 3,000 ft.	1	1.69	1	3.12
,, 2,000 to 4,000 ft.	1	1.70	1	3.12
.. 2,000 to 5,000 ft.	—	—	—	—
.. 2,000 to 6,000 ft.	—	—	—	—
,, 2,000 to 7,000 ft. & over	—	—	—	—
At 3,000 ft.	—	—	—	—
From 3,000 to 4,000 ft.	1	1.69	—	—
,, 3,000 to 5,000 ft.	—	—	—	—
.. 3,000 to 6,000 ft.	1	1.69	—	—
,, 3,000 to 7,000 ft. & over	2	3.39	—	—
At 4,000 ft.	—	—	2	6.25
From 4,000 to 5,000 ft.	—	—	1	3.12
,, 4,000 to 6,000 ft.	1	1.70	—	—
,, 4,000 to 7,000 ft. & over	8	13.56	—	—
At 5,000 ft.	—	—	—	—
From 5,000 to 6,000 ft.	—	—	—	—
,, 5,000 to 7,000 ft. & over	5	8.48	—	—
At 6,000 ft.	—	—	—	—
From 6,000 to 7,000 ft. & over	—	—	—	—
	59	100.00	32	100.00

In consideration of the fact that Composites are a temperate zone order, and the Asclepiads are tropical, it might be expected that the former would show a larger proportion of plants at high altitudes than the latter. The tables very well illustrates that this is actually the case with our Ceylon members of these two families. A reference to the concluding tables will show the altitudinal distribution of the endemics of both these orders and this needs no further comment here.

The order *Loganiaceae*, in Ceylon (here I follow Trimen as I have had no access to the revision of the order), is represented by 4 genera, and 14 species, of which 6 are endemic. The largest genus is *Strychnos*, which affords 3 indigenous species, as does *Gaertnera*. With the exception of *Mitrasacme*, which has a capsule, all are fleshy-fruited, but to what extent they are eaten by animals, I am in ignorance. None of our endemics in this order are found in our higher hills, with the exception of the shrubby *Gaertnera Walkeri*, which has bird-attractive (?) blue fruits.

The Ceylon members of the *Gentianaceae* are made up of 8 genera, and 19 species, of which 5 are endemic. *Exacum* is the largest genus, and affords 4 endemics, the remaining endemic being *Swertia zeylanica*. The whole order, with the solitary exception of *Crawfurdia* (and this appears to be almost extinct, judging by its "rarity") has capsular fruits. The transportation is difficult to account for. Possibly some of our forms may be water-carried, but this is uncertain, as so many are found growing in steep banks, and places where, though the soil is damp, there is no actual water in movement. On the other hand, I have found Gentians in swampy, wet ground.

The *Boraginaceae* is a moderately large order of 8 genera, and 18 species, of which only 2 are endemic. *Cordia* is the largest genus, having 5 species, one of which is peculiar to the country, the other endemic is *Tournefortia Walkerae*. Both the endemic species bear fruits that may be animal-eaten, and have hard seeds. None of our examples of this order occur in the highest parts of the Island.

The *Convolvulaceae*, in Ceylon, form 11 genera, and 46 species, of which only 3 are peculiar to the country. Seven of the genera only afford one speices each, while *Ipomaea* has no less than 29, of which *one* is endemic. The whole family are climbers, and excepting the parasitic *Cuscuta* do not possess attractive fruits; moreover, they are mostly short-lived.

I have no evidence to show that the fruits are ever animal-eaten, and I assume that transportation is mostly effected geomitridally, *Cuscuta* excepted, and this I think is bird-carried.

It is remarkable that, so well represented a family as the *Solanaceae* is, it has no endemic forms in Ceylon, and has the advantage of attractive fruits. It may be assumed that the fruits are poisonous, but this suggestion needs corroboration. I have frequently seen the fruits of these plants fallen on the ground and left untouched.

The large family of the *Scrophulariaceae* is, in Ceylon, represented by 16 genera, and 40 species, of which only 2, confined to *Adenosma*, are endemic. These two are confined to the low-country. The fruits

of these species are unattractive, and the species may be conveniently described as affecting swampy, or damp ground. Out of such surroundings, they do not appear to thrive, and consequently do not spread.

The curious family of root parasites, the *Orobanchaceae*, contains 3 genera in Ceylon, with 8 species, of which so far 3 are found to be endemic. It appears to be quite probable that the order may be found to be even larger than our records show, and a careful exploration of the "Peak Wilderness" will, I believe, result in the discovery of more. As I have no knowledge of the life-history of these curious plants, I can express no opinion as to their seed dispersal, or their seeming partiality for "Nellu" as a host.

The *Gesneraceae* are well represented in Ceylon by 7 genera, and 12 species, of which one genus and eight species are endemic. It will be observed from the tables that our indigenous forms, under this order, are well distributed, while it is equally noticeable that the fruits are not attractive, nor are the plants themselves more than herbs. *Didymocarpus Humboldtianus* is, in suitable places, equally well distributed in both sides of the Island, I have found it growing freely inside a small shallow cave on the side of the exposed wind-swept rock known as Koudagalla, to the north of Punnani in the Eastern Province, and again in very similar situations on the great cliff of "Westminster Abbey," in the south. It is not clear how, with such barren surroundings, this minute plant should appear at such remote places, and flourish. In the case of Koudagalla rock, the little cave where I found it is near the summit of the mountain, that is quite exposed to very severe tempests of dry wind. *D. zeylanicus* occcurs in abundance in damp shady banks in the valley of the Maskeliya ganga, near the Laxapana mountain. I preserved and grew several examples, but failed to raise seedlings.

The very handsome-flowered *Chirita Moonii* I have repeatedly obtained on wet rocks, where it grew in the crevices. *C. zeylanica* is fairly abundant, and seed-capsules, that I suspect as belonging to this, I have found in a manner suggestive of wind-transport.

Championia reticulata, our monotypic and endemic genus, is apparently confined to the very wet parts of the Sabaragamuwa Province, while *Klugia zeylanica* may be regarded as water-loving. The latter has membranous light capsules, easily water-carried.

I am unprepared to show satisfactory proof of the means of dispersal of seed in this family, but the deficient data I have is suggestive of the capsules being wind-carried in some, or water-carried in others. It is noteworthy that our non-endemic *Aeschynanthus zeylanica* is often found growing on the branches of trees,

The very large order *Acanthaceae* is, in Ceylon, represented by 29 genera, and 93 species. Of these, 39 are endemic, and one of the genera is monotypic.

The distribution of the whole order is remarkable. Of the endemics, as contrasted with the non-endemics, we have the following altitudinal range :

Range.	Endemic		Non-endemic	
	Number.	%	Number.	%
From 0 to 1,000 ft.	2	5.13	29	35.70
1,000 to 2,000 ft.	5	12.82	4	7 41
1,000 to 3,000 ft.	3	7.69	7	12.96
1,000 to 4,000 ft.	3	7.69	—	—
1,000 to 5,000 ft.	—	—	—	—
1,000 to 6,000 ft.	1	2.56	—	—
1,000 to 7,000 ft. & over	—	—	3	5.55
2,000 ft.	1	2.56	—	—
2,000 to 3,000 ft.	2	5.13	2	3.70
2,000 to 4,000 ft.	3	7.69	3	5.55
2,000 to 5,000 ft.	1	2.56	—	—
2,000 to 6,000 ft.	—	—	1	1.85
2,000 to 7,000 ft. & over	—	—	2	3.70
3,000 ft.	3	7.69	—	—
3,000 to 4,000 ft.	1	2.59	—	—
3,000 to 5,000 ft.	—	—	—	—
3,000 to 6,000 ft.	2	5.13	—	—
3,000 to 7,000 ft. & over	1	2.56	1	1.85
4,000 ft.	2	5.13	—	—
4,000 to 5,000 ft.	—	—	—	—
4,000 to 6,000 ft.	1	2.56	—	—
4,000 to 7,000 ft. & over	3	7.69	—	—
5,000 ft.	—	—	—	—
5,000 to 6,000 ft.	—	—	—	—
5,000 to 7,000 ft. & over	1	2.56	—	—
6,000 ft.	1	2.56	—	—
6,000 to 7,000 ft. & over	3	7.69	2	3.70
	39	100.00	54	100.00

From the above table it will be observed, that while our endemics are nearly equally divided in point of number of species up to 3,000 ft. altitude, the non-endemics practically belong to the lower levels, the contrast being more striking in the high ratio at the lowest range of non-endemics to endemics.

In habit, the whole order may be described as gregarious, but in *Strobilanthes* in particular, we find the additional limiting peculiarity of the plants only seeding at long intervals of time. This peculiarity must, to a great extent, affect the spread of seed. In connection with this phenomenon, I may add, that I have on two occasions of the fruiting of *Strobilanthes* found them to synchronise with plagues of rats, that vanished after the seed crops were over. I have also observed that during the season of seeding, jungle fowl were in extraordinary abundance, besides other ground-feeding birds. The non-endemic *Stenosiphonium Russellianum* also has its seeds eaten by the jungle fowl, which I have no doubt spreads it. The fruit dispersal of some of our species requires further examination, as it appears uncertain if the seeds of all are bird-eaten, or if some of them are not wind-carried.

The *Verbenaceae* is a moderately large order of 13 genera, and 26 species, of which only three are endemic. Two of these, however, belong to the largest genus.

The remarkable spread of our introduced *Lantana* is an instance of how an unrestrained species can overspread large areas, practically to the exclusion of others. *Lantana aculeata* is said to have been brought to Ceylon in 1826. It is now a common weed, of extraordinary abundance, extending from sea-level into the hill country, especially in the moist regions. It has been spread by birds, its fruits being eaten by many kinds, and it is only in recent years that it appears to have been, to some extent, checked by blight. Its allied form, *L. indica*, on the other hand, is exceedingly rare.

Equally common is the probably-introduced *Stachytarpheta indica*, that grows as a wayside plant, plentifully, but its method of seed dispersal is not obvious. *Callicarpa indica* is bird-carried, but not in abundance.

Premna, our largest genus, is practically confined to the low-country, *P. tomentosa* alone extending into the hills, though in the matter of abundance it is more of a low-country plant than otherwise. The endemic forms, *P. Thwaitesii* and *P. procumbens*, are both rare. Without specially detailing the individuals themselves, it may be said of the order, as a whole, that the fruits are attractive ; but the majority of its members are not strictly forest plants, and probably suffer much artificial destruction in consequence. The outstanding exception is *Vitex altissima*, it being found in forest lands and chenas alike. *Avicennia officinalis* is water-loving, and mangrove-like in habit.

The *Labiatae* form another large family in Ceylon, of 16 genera, and 42 species, of which 10 are indigenous. The genera are mostly small, in point of number of component species. *Plectranthus* and *Pogostemon*

supply three endemics each ; *Anisochilus* and *Scutellaria*, one each ; and *Coleus* two.

The method of seed transportation is not very clear, in view of the uninviting nature of the fruits. That some are water-carried, appears to be probable, but this can not be the case in certain forms of a subgregarious habit, where possibly the geomitridal method of spreading those particular types may account for them. I find that Pearson, in his Ceylon Patana flora, enumerated no less than nine of the order as occurring in our high-altitude grass lands alone, the open-land habitat being generally characteristic of the whole family.

The *Amarantaceae* comprise 11 genera, and 25 species, of which 3 are endemic in Ceylon, these last being confined to solitary examples in these genera. The whole family belongs to low altitudes, and, as many are eaten by the people in their curries, it is probable that these are, to some extent, man-spread. Several forms are found by water, making it likely that the light seeds are dispersed by this agency.

The *Podostemaceae*, to which family Dr. Willis has devoted much labour, is represented by 5 genera, and 7 species, of which 2 are endemic. All are water plants, attached to rocks and stones that become affected by the rise and fall of the water, according to the corresponding fluctuations of rainfall ; thus, at certain periods, the plants are continuously under water, while in the very dry weather they are exposed, and dry up. It is at this season that " the flowering and fruiting occurs."

The order *Nepenthaceae* has, in Ceylon, one genus and one species. This has been referred to already. It is a wet-zone plant, and common in wet soils. I am inclined to think that the form found in some of the Sabaragamuwa forests (in the Kukulu Korale, and at Hewissa, especially) may be found to be a distinct variety, as it is very much larger, and more a forest plant than the common *N. distillatoria*. The minute seeds are apparently water-carried.

The complicated order, *Piperaceae*, is composed of 2 genera, and 14 species, of which last 5 are endemic. Both climbing and herbaceous plants are represented by the Ceylon examples of this order, the former numbering 8 and the latter 6 species. The fruits in the climbing section are distinctly attractive, and may be bird-carried, but of this I have no proof. In the herbaceous group, on the other hand, the fruits are minute and inconspicuous, so that how these forms come to be found on isolated rocks, or on dead stumps of trees, is by no means clear. *Piper peltatum*, though not peculiar to the Island, occurs in ravines as a solitary (or at most so) plant at elevations up to 4,000 feet. Its occurrence in such places is remarkable.

The little order, *Myristicaceae*, is confined to one genus with 4 species, of which 2 are endemic. The first of the endemics, *M. zeylanica*, is uncommon. I have found it in the Eastern Province, at a little above sea-level, while *M. Horsfieldia* is tolerably abundant in the wet-zone. The fruits are eaten by mynas, and are also water-carried.

The *Monimiaceae*, which appear to be Malayan as well as Ceylonese, is represented here by the endemic genus *Hortonia*, of which we have two species. Of these, one is a water-side plant growing abundantly by streams in the west of the Island in the low wet-zone, and the second occurs in the forests of our western hills, above 4,000 feet. It will be noticed that, like the Dipterocarps, these plants,though allied to Malayan examples of the same order, adopt our western side of the country only.

The *Lauraceae* are represented by 10 genera, and 33 species, of which the large proportion of 23 are endemic. They may be classed as shrubs and trees, and all possess fruits that are bird-eaten. The altitudinal distribution of endemics and non-endemics is best understood by reference to the table on the following page.

It will here be seen that our endemic forms are much more abundant in the hill than in the low-country, while our non endemics scarcely appear above 2,000 ft.

The well-known cinnamon, though not peculiar to this Island, was probably much more widely distributed locally than at present ; but owing to the large trade in its valuable bark as a spice, it was, in all probability, exterminated in the middle hill country, and it is only in consequence of its being regularly cultivated now as a product for commercial use that it has survived.

The most largely represented genus is *Litsea*, of which we have 9 species. These are well distributed in the western parts of the Island, extending to our highest altitudes. *Actinodaphne* has no non-indigenous forms, and represents 7 species ; the next largest genus being *Cinnamomum* with 4 endemics out of 5 species.

In consideration of the fact that the fruits are freely eaten by birds, it is remarkable that our middle altitudes between 1,600 feet and 3,000 feet appear to have no lauraceous plants.

The *Proteaceae*—natives principally of Australia and the Cape of Good Hope—find a solitary representative in Ceylon in *Helicia zeylanica*, which is endemic here. Its purple-black fruits are probably bird-eaten, but evidence is wanted. Apparently, this isolated type is a survival of a once widely-spread family, that now has become southern only, and which may be replaced by *Grevillea*, that now thrives in a cultivated state.

Of the family *Thymelaeaceae*, in Ceylon, we have 4 genera, and 4 species, of which *Phaleria* and *Gyrinops* supply one endemic each. I

Lauraceae Range	Endemic		Non-endemic	
	Number	%	Number	%
0 to 1,000 ft.	2	8.70	4	40
1,000 to 2,000 ft.	3	13.—	1	10
1,000 ,, 3,000 ft.	2	8.70	1	10
1,000 ,, 4,000 ft.	2	8.70	2	20
1,000 ,, 5,000 ft.			1	10
1,000 ,, 6,000 ft.				
1,000 ,, 7,000 ft. & over				
2,000 ft.				
2,000 to 3 000 ft.				
2,000 ,, 4,000 ft.			1	10
2,000 ,, 5,000 ft.				
2,000 ,, 6,000 ft.				
2,000 ,, 7,000 ft. & over				
3,000 ft.				
3,000 to 4,000 ft.	2	8.70		
3,000 ,, 5,000 ft.				
3,000 ,, 6,000 ft.				
3,000 ,, 7,000 ft. & over	1	4.36		
4,000 ft.	1	4.36		
4,000 to 5,000 ft.				
4,000 ,, 6,000 ft.	3	13.00		
4,000 ,, 7,000 ft. & over	2	8.70		
5,000 ft.	1	4.36		
5,000 to 6,000 ft.				
5,000 ,, 7,000 ft. & over	1	4.36		
6,000 ft.				
6,000 to 7,000 ft. & over	2	8.70		
7,000 ft. & over	1	4.36		
	23	100.00	10	100.00

am unable to say if the fruits are animal-eaten. The whole family is composed of inconspicuous bushes, or small trees, of which the commonest is *Gyrinops Walla*, which occurs in some abundance in our wet forests. As it grows well as a pollard, it is frequently found in Chena lands, especially in damp places.

The *Loranthaceae* have 4 genera, and 25 species, of which no fewer than 10 are endemic. The fruits are attractive, and bird-eaten, but

I have only observed one particular bird—*Dicaeum erythrorhyncum*—that not only eats the fruit, but builds in *Loranthus*. Wait,[3] speaking of this bird, says : " In the forest it also feeds on the berries of jungle creepers." It is widely distributed in Ceylon at, as Mr. Wait says, " all elevations." The very rare *Acmonorhyncus vincens* (Legge's Flower-pecker) is also supposed to spread *Loranthus*, but as I have only once met with the bird, I am unable to confirm this statement. The altitudinal

Loranthus Range	Endemic		Non-endemic	
	Number	%	Number	%
From 0 to 1,000 ft.	2	20	1	6.66
1,000 ,, 2,000 ft.	1	10	2	13.33
1,000 ,, 3,000 ft.	2	20	1	6.66
1,000 ,, 4,000 ft.			3	20.—
1,000 ,, 5,000 ft.			1	6.66
1,000 ,, 6,000 ft.			1	6.66
1,000 ,, 7,000 ft. & over			2	13.34
2,000 ft.	1	10		
2,000 to 3,000 ft.				
2,000 ,, 4,000 ft.				
2,000 ,, 5,000 ft.				
2,000 ,, 6,000 ft.				
2,000 ,, 7,000 ft. & over				
3,000 ft.	1	10	1	6.66
3,000 to 4,000 ft.				
3,000 ,, 5,000 ft.				
3,000 ,, 6,000 ft.	1	10		
3,000 ,, 7,000 ft. & over	1	10	1	6.66
4,000 ft.				
4,000 ,, 5,000 ft.				
4,000 ,, 6,000 ft.				
4,000 ,, 7,000 ft. & over	1	10		
5,000 ft.			1	6.66
5,000 to 6,000 ft.				
5,000 ,, 7,000 ft. & over				
6,000 ft.				
6,000 to 7,000 ft. & over			1	6.66
	10	100.00	15	100.00

distribution of the family, however, is rather significant in the gaps which occur in the endemics and non-endemics alike It is, however, to be observed that the parasite is not equally common on all trees alike, and that there are certain trees on which no plant of this order ever occurs, so that the distribution may be affected, certain trees only being suitable for one particular *Loranthus* and not another.

Again, it may be that scarcity of suitable trees may secure isolation; thus the adoption of *Salvadora* at Mannar, or of old abandoned Tea trees in abandoned land at Dolosbage, may be merely instances where other suitable hosts were inconveniently few. I therefore suppose that the abundance or reverse of examples of this order is very much a matter of circumstance. The apparent increase of *Loranthus* around Bandarawela is probably because there are so few trees there.

The remarkable order *Balanophoraceae* is represented, in Ceylon, by a single genus, with one endemic, and one non-endemic species. I am quite unacquainted with the method of fruit dispersal of these strange plants.

The *Euphorbiaceae* is one of our largest orders, consisting of 43 genera, and 130 species. One genus is monotypic, and 45 species are endemic.

The largest genus is *Phyllanthus*, and it affords the greatest number of endemic forms (9 out of 20), but the fruits in this genus are not all apparently bird-attractive, so that the dispersal is not easily accounted for. Among the minute-fruited forms of this order are several that are water-loving, or adopt very moist surroundings, that may account for seed dispersal by water only. Others again are, probably, entirely geomitridally spread, and have survived after a long but slow natural system of progression, during which variation is conceivable.

Very roughly divided into conspicuous and inconspicuous or unattractive forms of fruit, I find that 56 represent the former, and 74 the latter, but this classification is obviously very incomplete, and liable to much modification, particularly in respect of those with capsular fruits that are coated with hair. How far these may be even the favourite fruits of certain birds appears to be unknown, and till this is more completely worked out, the question of the distribution of the fruit must remain uncertain.

The *Urticaceae* is another largely-represented order. In Ceylon we have 27 genera, and 62 species, but only 8 of these are endemic. *Ficus*, our largest genus in this order, has 21 species, of which 3 are endemic. Five other genera have only one endemic representative in each. Though *Ficus* is our largest genus, the individual species do not occur in any large numbers, even though the fruits are bird (and bat) eaten. In

Artocarpus nobilis we have a fruit that is devoured by man, as well as birds and monkeys. In *Allaeanthus*, however, fruit dispersal is doubtfully bird-carried, and equally so in *Elatostema*. *Pouzolzia* is made up of herbs with unattractive fruits. In *Debregeasia* we have a shrub and an epiphytic plant that bear attractive fruits that are bird-eaten.

It has been stated that the well-known jak fruit tree (*Artocarpus integrifolia*) is a forest tree in Ceylon. This is incorrect. In many places it may be found in rocky forest lands, the seeds having been brought there first by human agency.

The order *Hydrocharitaceae* consists in Ceylon of 7 genera, and 9 species, of which one is endemic. The whole family are fresh, or salt water plants, belonging entirely to the lowest altitude in the Island.

The *Burmanniaceae* consist of 2 genera, and 4 species, of which 2 are endemic. Our endemic forms are the saprophyte *Burmannia Championii*, that I have found growing in rotten bamboo leaves, in the wet forests of Sabaragamuwa, and the rare *Thismia Gardneriana*. I am not acquainted with the fruiting of either of the above.

The great order of *Orchideae*, the third largest in Ceylon, is made up of 61 genera, and 161 species, of which 78 are endemic. Three genera are also peculiar to the country.

I think that it would be unprofitable to make any analysis of distribution in this order, as I am not aware of any very definite data as to how the seed is carried, other than by wind.

We are confronted with other considerations, such as the varying character of the plants themselves in their place of growth, some being content with rock crevices, others on damp soil, stems of trees, moss-grown logs, or even dead stems of forest plants. With such a variety among the hosts as this, it follows that the individual examples possess modifications to adapt them to these complex and unequal surroundings. We have not, as far as I am aware, any data to show why such widespread variation exists in the selection—if that phrase may be used—of one particular form or species of tree to grow on, in preference to another, or a complete chain by which the epiphytic forms of orchids can be traced to the terrestrial, as it appears they must be.

I can not attempt to suggest any particular reason for the large number of endemic forms that this vast order has in Ceylon, especially as I am unacquainted with any detailed data bearing on particular methods of seed distribution in the plants themselves.

The order *Scitamineae* is made up of 14 genera, and 37 species, of which 17 are endemic. One genus is endemic.

It may be worthy of consideration to remark that in the *Orchidaee* the endemic species form 47.82 per cent. of the total species, while we find that in the *Scitamineae* we have 46 per cent.—a rather striking parallel, if not a significant one. The altitudinal distribution of the order is shown in the following table :—

Scitamineae Range	Endemic		Non-endemic	
	Number	%	Number	%
From 0 to 1,000 ft.	7	41.17	4	20
1,000 ,, 2,000 ft.	—	—	6	30
1,000 ,, 3,000 ft.	—	—	4	20
1,000 ,, 4,000 ft.	2	11.76	3	15
1,000 ,, 5,000 ft.	1	5.88	2	10
1,000 ,, 6,000 ft.	—	—	1	5
1,000 ,, 7,000 ft. & over	—	—	—	—
2,000 ft.	1	5.88	—	—
2,000 to 3,000 ft.	—	—	—	—
2,000 ,, 4,000 ft.	1	5.88	—	—
2,000 ,, 5,000 ft.	—	—	—	—
2,000 ,, 6,000 ft.	—	—	—	—
2,000 ,, 7,000 ft. & over	—	—	—	—
3,000 ft.	—	—	—	—
3,000 to 4,000 ft.	3	17.65	—	—
3,000 ,, 5,000 ft.	—	—	—	—
3,000 ,, 6,000 ft.	—	—	—	—
3,000 ,, 7,000 ft. & over	—	—	—	—
4,000 ft.	1	5.88	—	—
4,000 to 5,000 ft.	—	—	—	—
4,000 ,, 6,000 ft.	—	—	—	—
4,000 ,, 7,000 ft. & over	1	5.88	—	—
5,000 ft.	—	—	—	—
5,000 to 6,000 ft.	—	—	—	—
5,000 ,, 7,000 ft. & over	—	—	—	—
6,000 ft.	—	—	—	—
6,000 to 7,000 ft. & over	—	—	—	—
	17	100.00	20	100.00

It will be observed that both our endemic and non-endemic forms are more numerous from 2,500 feet downwards, and that the non-endemic forms scarcely touch those sections that start from 2,000 feet.

They affect damp ground, rocky land, and margins of streams, even in the forests of the dry country. The fruits of some, as in the cardamon, are eaten by monkeys, and probably jungle rats also prey upon them, as I have frequently found cases to support this suspicion. Water-transport is probably the chief means of dispersal, in addition to the geomitridal.

Of the *Dioscoreaceae* Ceylon has 2 genera, and 7 species, of which only one is endemic, viz., *D. intermedia*. This species occurs on both the western and eastern sides of the Island. Its seeds are winged. The non-endemics are not found at high altitudes, and, except cultivated forms, the order is not very abundant. The curious little *Trichopus zeylanica* is locally abundant, and affects damp soils. It's seeds are probably water-carried, while the fruits are frequently eaten by native children.

The *Liliaceae* are well represented in Ceylon, there being 12 genera, and 18 species, of which 2 are endemic. *Asparagus* is the largest genus, and affords one species peculiar to the country, *A. zeylanicus*, that occurs over a wide altitudinal range. The remaining endemic, *Urginea rupicola*, appears to be very rare, and confined to low altitudes. Our most common representatives of this order are non-endemic, and their means of transportation arouses interest, as it is not apparent how this is effected. *Gloriosa superba*, for example, presents the problem of being common by the sea-shore and plentiful, locally, at 2,500 ft. altitude in *forest* land. I have found this plant growing on soil on the top of an isolated rock, and again in deepish damp soil in abandoned chena land. It is notoriously poisonous, but is much eaten by a large caterpillar, especially in the wet-zone. Though much admired by Europeans for the beauty of its flowers, I do not think it is so frequently grown artificially as to account for its presence in isolated places, where I have repeatedly found it.

The *Commelinaceae* include 5 genera, and 30 species, of which 3 are endemic. These are *Commelina Thwaitesii*, *Cyanotis obtusa*, and *C. zeylanica*. The two former are rare : possibly *C. obtusa* (if it is endemic) by its isolation on Doluwa Kanda may be found only to be an environmentally altered form, as the situation of this lonely forest-covered rock appears to influence more than one family of plant, especially as at one time Doluwa Kanda was inhabited, and succulent plants may have been humanly introduced for fodder, if not for human use. *C. zeylanica* is common, and in places is a weed. Stems broken off will grow readily, and as the plant is readily eaten by goats, it is probably spread by them, just as goats have spread *Mimosa pudica*. Coolies on estates frequently carry plants of this order to their " lines," to feed cattle and goats, and

in consequence it is very frequently found that Commelinas are regular estate weeds.

The very important order *Palmaceae* has, in Ceylon, 10 genera, and 21 species, of which we have one endemic genus and a total of 11 endemic species.

In *Areca* we have 2 species, of which *A. concinna* is endemic. It is found, when in a natural state, in fresh-water swamps, locally called "Waturana lands," but only below 1,000 feet altitude. The fruits are bright scarlet, and attractive. *A. Catechu* is cultivated extensively. In certain parts of the wet-zone I have found this species growing wild, but only as "escapes" from abandoned gardens.

The monotypic *Loxococcus* is peculiar in its affection for rocky precipices, where it is generally to be found. On the very edges of some of our highest precipices, it occurs in abundance; but, while I have found several solitary palms of this species growing in rock crevices, or on brackets of rock, I have failed to find it right at the foot of the same cliffs. The fruits are of a rich red colour, and are eaten by monkeys, but why *L. rupicola* is apparently confined to circumscribed and precipitous spots, I am unable to discover a reason for.

Oncosperma fasciculatum, another endemic palm, to some extent, shares a similar habitat as the last. This species, however, does not always select the edge of a precipice, and is frequently found well in the heart of the forest, growing gregariously on thin crusts of soil. It's stem is provided with large, finely pointed, brittle spines, so that probably it is not visited by monkeys. The fruits are deep purple in colour, and bird-attractive.

Phoenix zeylanica is very abundant at low altitudes, on both sides of the Island. The fruits are small, red, and attractive.

Calamus is our largest genus, and has 7 endemic species, out of a total of 10. All have attractive fruits, and are both bird- and monkey-eaten.

Of our non-endemics, *Corypha*, *Borassus*, and *Cocos*, like *Areca Catechu*, are cultivated, while *Caryota urens* is so much employed by the people, and grows so readily, that it might almost be regarded as a domesticated species. It occurs, however, in a wild state in many of our wet and dry forests. I have found the seeds of this species in the excrement of monkeys, and *Jackals*. *Nipa fruticans* is rare, water-carried, non-endemic. It occurs in the south, and I have also found it in the east, but it is not common.

Our *Pandanaceae* consist of 2 genera, and 5 species, of which 3 are endemic. *Pandanus zeylanicus* occurs in a natural state in the beds of

streams, and is also cultivated. The fruits lend themselves to water-transportation. The locally small genus *Freycinetia* is confined to tree-climbing species, with highly attractive, brilliant coloured carpels. I have obtained *F. Walkeri* from the summit of the monsoon-scourged rock of Kunadiyaparawitta, where I have no doubt it was introduced by birds. It should be noted that, while both *F. pycnophylla* and *F. Walkeri* are both abundant in the wet country and are powerful tree-climbers, they are not to be found ascending all kinds of trees equally; thus, they are not to be found frequently on all Dipterocarps alike, nor have I found them confined to rough-barked trees, so that there appears to be a selective action at work, even in those localities where the genus is plentiful.

The order *Araceae* is composed of 15 genera, and 23 species, of which 14 are endemic. The two largest genera, *Cryptocoryne* and *Lagenandra*, of 5 species each, have 4 endemics apiece.

The family is widely distributed in Ceylon, but except *Pothos* (which is a scandent genus), it is confined to wet or damp places. The fruits are all, or nearly all, attractive, but are more probably water-carried, except in those cases where the plants are climbers. Several species are found, more or less cultivated, in gardens, and have run wild therefrom. In *Pothos*, the fruits are probably all bird-eaten.

The small order *Triurideae* consists of one genus, and 3 species, of which 2 are endemic. I am entirely unacquainted with the family.

The order *Naiadaceae*, according to Trimen, is composed of 5 genera, to which Willis[5] adds *Diplanthera*, which is included by Trimen in *Cymodocea*. There are 11 species, of which only one is endemic, *vide* Willis. The whole order is aquatic, and, excepting *Aponogeton crispum*, is confined to sea-level. *A. crispum* is found in running streams, up to 6,500 feet altitude.

The small order of the *Eriocaulonaceae*, consists of one genus, and 18 species, of which 7, or 38 %, are endemic.

As will be seen from the table opposite, the distribution of our indigenous members of this family, as contrasted with the non-endemics, is remarkable.

The fruits are very small, and membranous, and the seeds extremely minute. Their transportation in mud attached to the feet of wading birds is probable, but so far unauthenticated.

The *Cyperaceae* is one of Ceylon's largest orders, having 22 genera, and 161 species, of which only 12 are endemic. As will be seen by re-

Eriocaulon Range	Endemic		Non-endemic	
	Number	% of whole genus	Number	% of whole genus
1,000 ft.	4	22.22	4	22.22
1,000 to 3,000 ft.	—	—	1	5.55
1,000 ,, 4,000 ft.	—	—	2	11.12
1,000 ,, 5,000 ft.	—	—	—	—
1,000 ,, 6,000 ft.	—	—	—	—
1,000 ,, 7,000 ft. & over	—	—	—	—
2,000 ft.	—	—	—	—
2,000 to 3,000 ft.	—	—	—	—
2,000 ,, 4,000 ft.	—	—	—	—
2,000 ,, 5,000 ft.	—	—	—	—
2,000 ,, 6,000 ft.	—	—	—	—
2,000 ,, 7,000 ft. & over	—	—	—	—
3,000 ft.	—	—	—	—
3,000 to 4,000 ft.	—	—	—	—
3,000 ,, 5,000 ft.	—	—	—	—
3,000 ,, 6,000 ft.	—	—	1	5.55
3,000 ,, 7,000 ft. & over	—	—	1	5.55
4,000 ft.	—	—	—	—
4,000 to 5,000 ft.	—	—	—	—
4,000 ,, 6,000 ft.	—	—	1	5.55
4,000 ,, 7,000 ft. & over	—	—	—	—
5,000 ft.	—	—	—	—
5,000 to 6,000 ft.	—	—	—	—
5,000 ,, 7,000 ft. & over	2	11.12	1	5.55
6,000 ft. & over	1	5.55	—	—

ference to the tables of distribution, few reach our high altitudes, *Carex lobulirostris* being the only species to reach 7,000 feet and over. It will be noticed that our total number of endemic cyperaceous plants only amounts to 7.45 % the whole order ; while of the genera, 27.25 % have endemic representatives.

Dividing the order into endemic and non-endemic branches, the altitudinal distribution is thus analysed:—

Range.	*Cyperaceae.* Endemic.		Non-endemic.		*Gramineae.* Endemic.		Non-endemic.	
	No.	%	No.	%	No.	%	No.	%
1,000 ft.	5	41.66	64	42.95	9	29.03	82	39.61
1,000 to 2,000 ft.	—	—	9	6.34	1	3.23	31	15.—
1,000 ,, 3,000 ft.	1	8.33	22	14.76	—	—	13	6.28
1,000 ,, 4,000 ft.	—	—	9	6.04	—	—	20	9.66
1,000 ,, 5,000 ft.	—	—	4	2.68	1	3.23	2	.96
1,000 ,, 6,000 ft.	—	—	5	3.35	—	—	3	1.45
1,000 ,, 7,000 ft. & over	—	—	4	2.68	—	—	11	5.31
2,000 ft.	—	—	—	—	1	3.23	—	—
2,000 to 3,000 ft.	—	—	1	.67	—	—	2	.96
2,000 ,, 4,000 ft.	—	—	—	—	2	6.45	8	3.86
2,000 ,, 5,000 ft.	—	—	—	—	—	—	1	.48
2,000 ,, 6,000 ft.	—	—	2	1.34	—	—	4	1.93
2,000 ,, 7,000 ft. & over	—	—	1	.67	—	—	3	1.45
3,000 ft.	2	16.66	—	—	1	3.23	2	.96
3,000 to 4,000 ft.	—	—	1	.67	1	3.23	3	1.45
3,000 ,, 5,000 ft.	1	8.33	2	1.34	1	3.23	1	.45
3,000 ,, 6,000 ft.	—	—	1	.67	—	—	1	.48
3,000 ,, 7,000 ft. & over	—	—	1	.67	—	—	2	.96
4,000 ft.	—	—	2	1.34	1	3.23	—	—
4,000 to 5,000 ft.	—	—	1	.67	—	—	1	.48
4,000 ,, 6,000 ft.	1	8.33	3	2.02	3	9.67	2	.96
4,000 ,, 7,000 ft. & over	—	—	11	7.38	—	—	8	3.86
5,000 ft.	—	—	—	—	2	6.45	2	.96
5,000 to 6,000 ft.	—	—	1	.67	2	6.45	—	—
5,000 ,, 7,000 ft. & over	1	8.33	3	2.02	1	3.23	1	.48
6,000 ft.	1	8.33	—	—	2	6.45	—	—
6,000 ,, 7,000 ft. & over	—	—	2	1.32	2	6.45	3	1.45
7,000 ft.	—	—			1	3.23	1	.48
	12	100.00	149	100.00	31	100.00	200	100.00

I had the unique opportunity of observing the first forms of vegetation in the bed of a tank that had burst, after being full of water for about 60 years.

This was the Haliella Tank, in the Matara District. The entire watershed of the tank did not extend above 1,000 feet altitude, and mostly from forest-clad land, so that the plant forms could only be expected to come from a correspondingly low level. The tank itself covered approximately 400 acres, and at no place did the depth of water exceed 50 feet, so that in section it formed a narrow wedge longitudinally, and two narrow wedges, back to back, if taken transversely. I paid a number of visits to the tank in order to observe the first forms of vegetation, and their relative density.

By far the largest number were *Cyperaceae*. The second most abundant were two species of *Cassia*, followed by scrophulariaceous plants. All the large-fruited plants were absent, though I collected several decomposed examples. Later, composites formed along the wet or moist edges of the hollows, but these, I consider, were late arrivals, and wind-carried.

Unfortunately, my notes were all destroyed, white ants having devoured my note-book, so I am unable to record, in detail, the particulars of the individual species examined and tabulated at the time. However, the facts go to show that the survivors, after a long period of total saturation, were only those that had hard horny seeds, and that undoubtedly these were water-carried. The inference to be drawn is rather important, and possibly bears on the large percentage of hard-seed bearing plants being found crowding the banks of rivers in the low-country, and the beds of non-perennial streams in the dry-zone. It will be observed that, in our Ceylonese *Cyperaceae*, by far the highest number of endemics and non-endemics alike belong to the lowest strata of altitude.

The *Gramineae* is our largest order in Ceylon, and is made up of 83 genera, and 240 species, of which 31 are peculiar to the Island. These 31 endemics are distributed over 19 genera, but no one genus is confined to this country. It will be noticed that, while the genera are exceedingly numerous, they only average about 3 species in each.

I have placed alongside of the table of *Cyperaceae* the corresponding figures to show the altitudinal distribution of the grasses, but I regret that I cannot accept the data there given with full confidence, as there is much room for supposing that a new revision of our Ceylon grasses is desirable, the material on which Sir J. D. Hooker compiled his work being incomplete.

Faulty though these figures may be, they show that our grasses have a remarkable diversity of distribution, but, as already referred to, this is entirely governed by the diversity of our Patana and Talawa lands. The extent to which man has played a part in the distribution of grasses probably can not be estimated, but the fact that grasses play a most important part in his domestic economy, directly and indirectly, can not be overlooked

Finally, the dispersal by birds and animals supplements the method of dissemination. It is more than probable that many birds, in constructing their nests, transport grass that is in seed at the time, and in this way introduce a few individuals that afterwards spread. It is not necessary to detail the number that are wind and water-carried, as this is sufficiently well-known.

With the *Gramineae* I close my list of Ceylon plants, and their endemic distribution.

It will be seen that out of a total of 149 orders, 89, or 59%, have endemic species, and it is of these endemics that I have detailed a table to show their individual distribution, as far as I am able to discover from the material at hand.

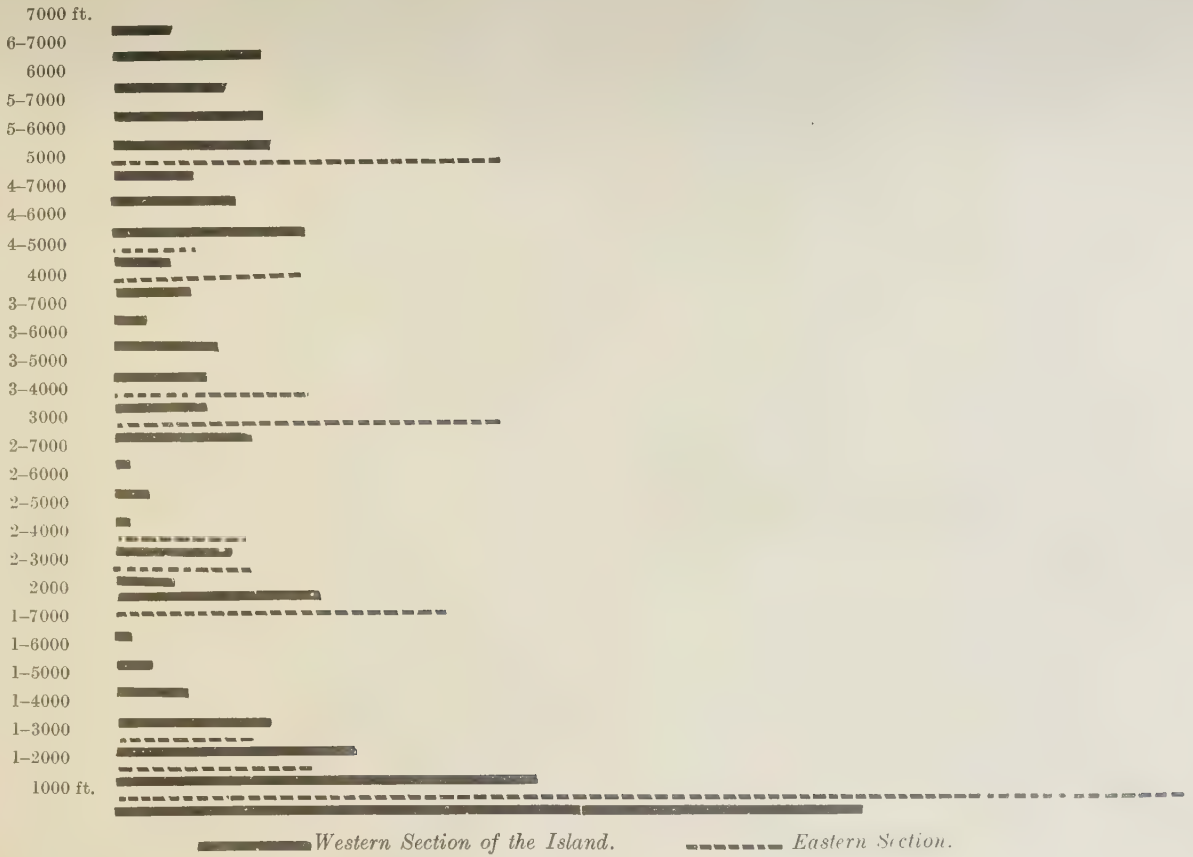
Classified into numbers having specific altitudinal distribution, the following table will be found helpful:—

Of the total of 804 recorded endemics, I have deducted 17, as either having insufficient material to establish identity, or in some cases where locality is not recorded. Where an endemic is found on both sides of the Island it will be included in the western aspect only, and a * showed as indicating western, as well as eastern, where no examples specially occur in the eastern side alone.

Range.	Western aspect.		Eastern aspect.	
	Number	%	Number	%
1,000 ft.	195	27.04	32	48.48
1,000 to 2,000 ft.	85	11.80	3	4.54
1,000 ,, 3,000 ft.	41	5.68	2	3.03
1,000 ,, 4,000 ft.	26	3.61	*	—
1,000 ,, 5,000 ft.	12	1.67	—	—
1,000 ,, 6,000 ft.	6	.83	*	—
1,000 ,, 7,000 ft. & over	3	.42	—	—
2,000 ft.	36	5.00	5	7.60
2,000 to 3,000 ft.	11	1.52	2	3.03
2,000 ,, 4,000 ft.	21	2.91	2	3.03
2,000 ,, 5,000 ft.	2	.27	—	—
2,000 ,, 6,000 ft.	6	.84	—	—
2,000 ,, 7,000 ft. & over	2	.27	—	—
3,000 ft.	23	3.19	7	10.62
3,000 to 4,000 ft.	15	2.08	3	4.54
3,000 ,, 5,000 ft.	15	2.08	*	—
3,000 ,, 6,000 ft.	18	2.50	—	—
3,000 ,, 7,000 ft. & over	5	.69	—	—
4,000 ft.	13	1.80	3	4.54
4,000 to 5,000 ft.	9	1.25	1	1.51
4,000 ,, 6,000 ft.	34	4.71	*	—
4,000 ,, 7,000 ft. & over	21	2.91	—	—
5,000 ft.	14	1.94	6	9.10
5,000 to 6,000 ft.	28	3.88	*	—
5,000 ,, 7,000 ft. & over	25	3.46	—	—
,, 6,000 ft.	19	2.63	*	—
6,000 ,, 7,000 ft. & over	26	3.63	—	—
7,000 ft. & over	10	1.39	—	—
	721	100.00	66	100.00

This table, when expressed in the form of a graph, conveys the above figures in a more striking form.

Graph illustrating the percentage of Endemics at different altitudes, and for both Sections of the Island.



The table and the graph both illustrate the percentage of our endemics at certain definite altitudes, and they show more or less strikingly, that the greater number of endemics are to be found at the foot of the hills, instead of at our highest altitudes. It suggests itself that this is explained by gravitational action, by which streams carry down seeds, or fruits, that in turn over-populate the lower levels, and in so doing set up a larger struggle for existence ; and by the operation of the law of natural selection, the strugglers develop latent forces, that in turn become specifically divergent, and consequently evolve a type, so modified as not only to survive, but to constitute a distinct form. This "form," owing to its divergence, we class as a distinct or endemic species.

Had the struggle not been so intense, it is probable that the necessity for divergence would not have existed, and "new species" would have been fewer. But the stage would arise (provided extraneous influences of an unforeseen nature were absent), when the "new species" would war against other "new species," till by the same process a "more fit" was developed, that would persist at the expense of *its* surroundings. No dynamical law could be laid down by which we could determine the *time* required for one series to dominate a second, to the extermination of the last. Not only does the personal or individual equation come in, but the presumption must arise as to the individual's tenacity, vitality, or degree of immunity from disease, that might even cause extinction.

The problem is beset with other influences, such as soil, or climate, or that ever-variable source of danger—man. Man has brought fire and the axe—two of the most disruptive forces in plant life. No better illustration of this could be found in this country than by comparing a "virgin forest," with a "chena land" that has been abandoned for 15 or 20 years. The difference produced, though natural in its result, is the outcome of an artificial partial destruction. To bring back the "chena" to the original conditions before the land was "chenaed," would probably be impossible, but it could hardly be contended that this impossibility of reconstruction is due to a spontaneous generation of new species. The changed conditions might conceivably produce a retroversion to a form that had once existed, but which, through environmental pressure, had long since changed its form or habit, till this sudden liberation by the accident of man's interference.

The presence of a form on the two sides of a vast valley, identical in appearance, may be occasioned by the simultaneous departure in opposite directions of an organism capable of reproducing itself without the aid of adventitious agents of transportation. Such a progression (which I have ventured to call geomitridal), would be obviously slower

than if the fruit, or seed, was carried by some bird or beast ; but it is probable, that, in the course of its pilgrimage, a much more elaborate modification would be evolved, making the divergence from the original stock so marked, as practically to cut itself away completely from recognition as having been once the same thing, as we recognise it under another name at its place of primary incidence.

I have not attempted to bring to bear upon my subject the " rarity," or otherwise, of a plant. This " rarity " may be accounted for in other ways, and is not, I think, a safe guide by which to assume a special importance. Till we can have a mathematical knowledge of the number of plants we have in a country of one kind, as compared with that of another, we can only assume that " rarity " depends more on individual success in collecting than what the actual word implies. If we accept " rarity " as meaning a ratio, we must have the actual factors before we can get at that ratio, so that the expression cannot, as it stands, do more than express an indefinite ratio of commonness, and therefore no certain index of the actual state of affairs. Again, " rare " may mean as regards the country as a whole, though within a circumscribed area the individual may be exceedingly common.

Till our explorations are more complete and systematic, I venture to think that no specific value can be attached, except in a general sense, to the word " rare," and for that reason, where I have used it, I do so with reservation.

I have drawn my deductions from such material as I have at hand, and I must leave it to conjecture if our distribution of endemics is based on correct grounds or not. In advancing the following table, therefore, I am guided entirely by the recorded instances, showing the species collected, and where from ; and this data will doubtless be amplified, or modified, as more material becomes available.

The marginal notes are included as bearing (1) on special colouring of fruits ; (2) rarity ; (3) perfection or imperfection of material on which the species is locally described.

The figures in the vertical columns indicate the altitude at which the material has been obtained.

TABLE OF CEYLON ENDEMIC PLANTS, SHOWING ALTITUDINAL DISTRIBUTION

(Endemic Genera in Capitals)

Orders	Genus	Species
No. 1 **Ranunculaceae.**	*Ranunculus*	*sagittifolius*
2 **Dilleniaceae.**	*Acrotrema*	*uniflorum*
		intermedium
		lanceolatum
		Gardneri
		Thwaitesii
		dissectum
		lyratum
	SCHUMCHERIA	*castaneaefolia*
		alnifolia
		angustifolia
	Wormia	*triquetra*
	Dillenia	*retusa*
3 **Magnoliaceae.** No endemics		
4 **Anonaceae.**	*Uvaria*	*sphenocarpa*
		macropoda
	Unona	*elegans*
		zeylanica
	Polyalthia	*Mooni*
		persicifolia
		acuminata

TABLE OF CEYLON ENDEMIC PLANTS, SHOWING ALTITUDINAL DISTRIBUTION

(Endemic Genera in Capitals)

Fruit.	Western.							Eastern.							Remarks
	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	
Achenes						×	×								
do		×	×	×											
do	×	×													Rare
do		×	?	?	×										Rare
do			×												
do		×													Very rare
do		×													Very rare
do		×													Very rare
do	×														
do				×	×										
do	×														Rare
Fleshy	×	×	×	×	×										
do	×	×													
do	×	×						×							
do		×													Brilliant fruits
do	×								×						
do		×													Scarlet fruits
do	×														Red fruits
do	×														
do	×														Rare

Orders		Genus	Species
No. 4	**Anonaceae.** (*Contd.*)	*Xylopia*	*parvifolia*
			nigricans
			Championii
		Goniothalamus	*Gardneri*
			Hookeri
			Walkeri
			Thomsoni
			reticulatus
			salicinus
		Bocagea	*Thwaitesii*
			obliqua
			coriacea
		Miliusa	*zeylanica*
		Alphonsea	*sclerocarpa*
5	**Menispermaceae.**	No endemics	
6	**Berberideae.**	do	
7	**Nymphaeaceae.**	do	
8	**Cruciferae.**	do	
9	**Capparideae.**	do	
10	**Violaceae.**	*Ionidium*	*ramosissimum*
		Alsodeia	*virgata*
11	**Bixaceae.**	*Scolopia*	*crassipes*
			Gaertneri
		Erythrospermum	*phytolaccoides*

Fruit	Western							Eastern							Remarks
	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	
Fleshy	×										×				
do	×									×					Rare
do	×	×													
do		×													
do		×													
do	×														Very rare
	×														Very rare
do	×														Very rare
do	×	×	×	×	×										
do	×	×	×	×											
do	×														Pinkish red fruit
					×	×									
	×														Hard bony fruit
Ovoid								×							Very rare
Dry capsule								×	×						Very rare
Globose	×							×							
Fleshy berry			×	×	×										
do	×							×							
Spherical	×														Scarlet arils

Orders		Genus	Species
No.11 **Bixaceae.** (*Contd.*)		*Aberia*	*Gardneri*
		TRICHADENIA	*zeylanica*
		Hydnocarpus	*venenata*
			octandra
12 **Pittosporaceae.**		*Pittosporum*	*zeylanicum*
13 **Polygalaceae.**		*Polygala*	*glaucoides*
		Salomonia	*cordata*
14 **Caryophyllaceae.**		*Stellaria*	*drymarioides*
15 **Portulacaceae.**	No endemics		
16 **Tamariscineae.**	do		
17 **Elatineae.**	do		
18 **Hypericaceae.**	do		
19 **Guttiferae.**		*Garcinia*	*echinocarpa*
			terpnophylla
		Calophyllum	*Burmanni*
			bracteatum
			Thwaitesii
			trapezifolium
			cuneifolium
			cordato-oblongum
			Walkeri

Fruit	Western						Eastern							Remarks
	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	
Globular		×	×												
Berry	×														
do	×	×						×	×						Water-carried
Globose	×							×							
Capsule		×	×	×	×	×					×	×			Red testa, pulpy
	×														Common in open land
	×														On wet ground
do					×										(Once found only!)
Spinous				×	×	×						×	×		Economic
Ovoid	×	×	×												
do	×							×							Bright red fruit
do	×														
do	×	×	×	×											
Globular											×	×			Rare
										×					Very rare
do	×														Very rare
do					×	×	×						×		Swampy land

Orders	Genus	Species
No.19 **Guttiferae.** (*Contd.*)	*Kayea*	*stylosa*
	Mesua	*Thwaitesii*
20 **Ternstroemiaceae.**	*Ternstroemia*	*emarginata*
	Adinandra	*lasiopetala*
	Gordonia	*zeylanica*
		speciosa
21 **Dipterocarpaceae.**	*Dipterocarpus*	*hispidus*
		zeylanicus
		scabridus
		glandulosus
	Shorea	*oblongifolia*
		Dyeri
		reticulata
		stipularis
	DOONA	*zeylanica*
		affinis
		Gardneri
		nervosa
		trapezifolia
		congestifolia
		cordifolia

Fruit	Western							Eastern							Remarks
	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	
Spherical	×														Very rare
Sub-globose	×														Water-loving
Ovoid					×	×									Water-loving
Fleshy					×	×									
Capsule					×	×	×						×		Seed-winged
			×												Seed-winged
Winged	×														
do	×	×	×								×				
do	×														Very rare
do	×	×													
do	×														
do		×													Doubtful location
do			×												Material wanted
do	×	×													
do		×	×	×											
do		×													
do			×	×	×										
do	×														
do	×	×													
do	×	×													
do	×										×				

Orders	Genus	Species
No.21 **Dipterocarpaceae.** (*Contd.*)	DOONA	*ovalifolia*
		oblonga
		venulosa
		macrophylla
	Hopea	*discolor*
		jucunda
		cordifolia
	Sunaptea	*scabriuscula*
		disticha
	Vatica	*affinis*
		obscura
	Balanocarpus	*zeylanicus*
	Vateria	*acuminata*
	STEMONOPORUS	*Wightii*
		Gardneri
		acuminata
		lanceolatuus
		affinis
		rigidus
		caniculatus
		petiolaris

Fruit	Western							Eastern							Remarks
	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	
Winged	×														
do	×														
															Material wanted
do	×														
do		×													
do	×														Water-loving
do															do rare
do	×														Rare
do	×														Material wanted
Ovoid	×														Water-loving
do								×							Gregarious by streams
do															Confined to Dolowakanda
Spongy	×	×													Common near water
Ovoid	×														
Ovoid				×											
Globular								×							
Globose			×												Very rare
do				×								×			
															Very rare
Globular	×														
?	×														Very rare

Orders	Genus	Species
No.21 **Dipterocarpaceae.** (*Contd.*)	STEMONOPORUS	*oblongifolius*
		reticulatus
		nitidus
		nervosus
		Moonii
		Lewisianus
		revolutus
	MONOPORANDRA	*cordifolia*
		elegans
21A **Ancistrocladaceae.**	*Ancistrocladus*	*Vahlii*
22 **Malvaceae.**	*Dicellostyles*	*axillaris*
	JULOSTYLES	*angustifolia*
23 **Sterculiaceae.**	*Sterculia*	*Thwaitesii*
24 **Tiliaceae.**	PITYRANTHE	*verrucosa*
	Grewia	*diplocarpa*
	Triumfetta	*glabra*
	Elaeocarpus	*obovatus*
		montanus
		zeylanicus
		glandulifera
25 **Linaceae.**	*Hugonia*	*ferruginiea*

Fruit	Western							Eastern							Remarks
	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	
Globular				×											Very rare
Large do															Very rare
Globular															
															Doubtful
?	×														Water-loving
Globose															Very rare
do															Very rare
Globular															
Globose		×													Very rare
Winged	×														In wet soils
Ribbed															Very rare
Globular	×	×													Fruit densely stellate
Woody follicles															Very rare
Dry															
Dry, 4-lobed															
Hooked															
Drupe							×								Rare
Globular							×	×							Very rare
Ovoid, smooth															Very rare
Ovoid, glaucous					×	×	×	×							
?	×														

Orders		Genus	Species
No.25 **Linaceae.** (*Contd.*)		*Erythroxylon*	*acuminatum*
			obtusifolium
26 **Malpighiaceae.**	No endemics		
27 **Zygophyllaceae.**	do		
28 **Geraniaceae.**		*Biophytum*	*nervifolium*
			nudum
			proliferum
		Impatiens	*glandulifera*
			macrophylla
			repens
			leptopoda
			truncata
			janthina
			Hookeriana
			subcordata
			leucantha
			linearis
			appendiculata
			elongata
			cornigera
			Arnottii

Fruit	Western							Eastern							Remarks
	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	
Drupe	×							×							
do	×	×	×							×					Scarlet fruit
Capsule								×							
do				×	×	×									
do					×	×	×								
do				×	×	×									
do				×	×	×	×								
do	×	×								×					
do						×									
do					×	×	×								
do	×	×													Very rare
do		×		×	×	×				×					
do				×	×	×									
do	×														Very rare
do			×												
do	×	×	×	×	×										
do				×	×										Very rare
do	×														
do	×	×	×												

Orders		Genus	Species
No.28	**Geraniaceae**, (*Contd.*)	*Impatiens*	*Walkeri*
29	**Rutaceae.**	*Glycosmis*	*bilocularis*
		Murraya	*Gleniei*
30	**Simarubaceae.** No endemics		
31	**Ochnaceae.**	*Ochna*	*rufescens*
32	**Burseraceae.**	*Canarium*	*brunneum*
			zeylanicum
33	**Meliaceae.**	*Munronia*	*pumila*
		Aglaia	*apiocarpa*
		PSEUDOCARAPA	*Championii*
		Walsura	*Gardneri*
34	**Chailletiaceae.** No endemics		
35	**Olacineae.**	*Olax*	*zeylanica*
		Apodytes	*Gardneriana*
36	**Ilicineae.**		
37	**Celastraceae.**	*Euonymus*	*revolutus*
			Thwaitesii
			Walkeri
		Microtropis	*Wallichiana*
		Gymnosporia	*fruticosa*
		Kurrima	*zeylanica*

Fruit	Western							Eastern							Remarks
	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	
Capsule						×									Rare
Berry															Very rare
do															
Carp.															Very rare
Ovoid, hard															
Oblong ovoid															
Dry capsule															Medicinal
Fleshy															
Globose	×														Red arils
Ovoid															White arils
Drupe	×														Scarlet fruit
Compressed drupe						×	×								
Capsule															
do		×													Coloured aril
do															Coloured aril
do															
Minute		×													Crimson seed. Very rare
Fleshy	×	×	×	×				×							Fleshy sweet aril

Orders		Genus	Species
No. 38 **Rhamnaceae.**		*Zizyphus*	*napeca*
		Rhamnus	*Arnottianus*
39 **Ampelideae.**		*Vitis*	*glyptocarpa*
			lonchiphylla
			acuminata
			Gardneri
			reticulata
40 **Sapindaceae.**		*Allophylus*	*hispidus*
		GLENIEA	*zeylanica*
		Sapindus	*erectus*
			Thwaitesii
41 **Sabiaceae.**	No endemics		
42 **Anacardiaceae.**		*Mangifera*	*zeylanica*
		Semecarpus	*marginata*
			subpeltata
			pubescens
			obovata
			Moonii
			coriacea
			Walkeri
			Gardneri

Fruit	Western							Eastern							Remarks
	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	
Fleshy	×														
do						×	×								
Succulent	×	×						×							
do	×														
do	×							×							
do			×	×	×	×				×	×	×			Purple fruits
do	×														Pink fruits
Ovoid	×														Red fruits
Fleshy	×							×							Sweet fruits
do	×														
?	×														Very rare
Fleshy	×	×						×	×						Man, monkey, and bird-eaten
Fleshy recept	×	×	×												
do	×														
do	×														Very rare
do	×														
do	×														Very rare
do				×	×	×				×					
do	×	×													
do	×	×													

Orders	Genus	Species
No.42 **Anacardiaceae.** (*Contd.*)	*Semecarpus*	*acuminata*
		nigroviridis
		obscura
		parvifolia
		laevigata
	Campnosperma	*zeylanicum*
43 **Connaraceae.**	*Connarus*	*Championii*
	Ellipanthus	*Thwaitesii*
44 **Leguminosae.**	*Crotalaria*	*multiflora*
		Walkeri
	Desmodium	*jucundum*
	Derris	*paniculata*
		parviflora
	Sophora	*violacea*
		zeylanica
	PERICOPSIS	*Mooniana*
	Dialium	*ovoidium*
	Crudia	*zeylanica*
	Pithecolobium	*geminatum*
45 **Rosaceae.**	*Pygeum*	*zeylanicum*
	Agrimonia	*zeylanica*

Fruit	Western							Eastern							Remarks
	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	
Fleshy recept	×														Very rare
do			×	×	×	×									
do		×						×	×						
do	×														Very rare
do															Material wanted
Pulpy	×	×													Gregarious habits
Fleshy aril	×	×	×	×				×							Aril coloured
do		×	×						×						Pink aril
Dry pod				×	×	×									Patina plant
do				×	×										
do									×						Very rare
do									×						Very rare
		×						×							
Pod	×							×							Very rare
do				×	×	×	×		×						
do	×														Water-loving
Sweet								×							Man and monkey-eaten
	×														Very rare
Pod								×							
	×														
				×	×	×	×								

Orders		Genus	Species
No.45	**Rosaceae.** (*Contd.*)	*Poterium*	*indicum*
46	**Saxifragaceae.** No endemics		
47	**Crassulaceae.** do		
48	**Droseraceae.** do		
49	**Haloragiaceae.** do		
50	**Rhizophoraceae.**	*Serpicula*	*zeylanica*
		Carallia	*calycina*
		Anisophyllea	*zeylanica*
51	**Combretaceae.**	*Terminalia*	*parviflora*
52	**Myrtaceae.**	*Eugenia*	*cylindrica*
			Fergusoni
			subavenis
			micrantha
			sylvestris
			assimilis
			cordifolia
			Neesiana
			cyclophylla
			rotundifolia
			sclerophylla
			oligantha
			olivifolia

Fruit	Western							Eastern							Remarks
	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	
															Very rare
Small	×	×													
do	×	×													Pigeon-eaten fruits
do	×	×	×												
Ovoid	×	×	×					×							Bird-eaten fruits
Fleshy fruit	×														
do					×										
do					×	×									
do			×												Readily eaten by birds and fruit-bat
do	×	×													
do	×	×	×	×	×										
do	×	×	×	×	×										
Fleshy	×	×	×												
do							×								Very rare
do				×	×	×									
do					×	×									
do		×	×	×	×										
do	×	×													

Fruits eaten by birds and monkeys.

Orders	Genus	Species
No.52 **Myrtaceae.** (*Contd.*)	*Eugenia*	*Haeckeliana*
		terpnophylla
		xanthocarpa
		rufo-fulva
		phillyraeoides
		flocifera
		rivulorum
		fulva
		insignis
		decora
		rotundata
		Mabaeoides
		aprica
		amoena
		pedunculata
		Thwaitesii
	Barringtonia	*zeylanica*
53 **Melastomaceae.**	*Osbeckia*	*Rheedii*
		Walkeri
		buxifolia
		rubicunda

Fruit	Western							Eastern							Remarks
	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	
Fleshy	×														Very rare
do	×	×	×												Rare
do	×														Very rare
do	×														Rare
do											×				Very rare
do	×														Very rare
do	×														Very rare
do	×														Very rare
do	×														Very rare
do	×														Very rare
do		×													Scarlet fruit
			×	×	×	×									
											×				Very rare
?	×	×													Very rare
?															
Fleshy		×										×			Crimson fruit
Large, leathery	×														
Small, round						×	×								Water-loving
do						×	×								
do							×								Water-loving
do					×	×	×								

Fruits eaten by birds and monkeys.

Orders	Genus	Species
No.53 **Melastomaceae.** (*Contd.*)	*Osbeckia*	*Moonii*
	Sonerila	*zeylanica*
		rhombifolia
		Wightiana
		hirsutula
		Gardneri
		robusta
		lanceolata
		pilosula
	Medinilla	*fuchsioides*
		maculata
	Memecylon	*Arnottianum*
		Gardneri
		Hookeri
		parvifolium
		varians
		elongatalum
		ellipticum
		macrophyllum
		ovoideum
		revolutum

Fruit	Western							Eastern							Remarks
	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	
Small, round	×														Rare
Capsule		×	×												
do	×														
do															Rare
do						×	×								Rare
do															Very rare
do							×								Very rare
do	×	×													
do		×													Very rare
Soft						×	×								Epiphytic
do		×	×												Epiphytic
Berry	×														
do	×	×	×	×											Purplish fruit
do		×													do rare
do															Black fruit
do															
do		×													Purple. Very rare
do	×														
do	×														
do			×	×											Purple fruit. Very rare
do															Purple fruit. Very rare

Eaten by many kinds of birds.

Orders		Genus	Species
No.53 **Melastomaceae.** (*Contd.*)		*Memecylon*	*orbiculare*
			procerum
			cuneatum
			Clarkeanum
			fuscescens
			rostratum
			phyllanthifolium
			rhinophyllum
			leucanthum
			macrocarpum
			capitellatum
54 **Lythraceae.**		*Axinandra*	*zeylanica*
55 **Onagraceae.**	No endemics		
56 **Samydaceae.**		*Casearia*	*coriacea*
		Osmelia	*Gardneri*
57 **Passifloraceae.**	No endemics		
58 **Cucurbitaceae.**		*Trichosanthes*	*integrifolia*
		Momordica	*denudata*
		Melothria	*zeylanica*
59 **Begoniaceae.**		*Begonia*	*tenera*
			Thwaitesii

Fruit	Western							Eastern							Remarks
	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft	5,000 ft.	6,000 ft.	7,000 ft.	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft	7,000 ft.	
Berry		×													Small fruit. Very rare.
do	×														Small fruit, rare
do		×													Rare
do		×	×	×											Rare Yellow fruit
do	×														
do			×	×						×					
do					×										Very small fruit. Very rare
do	×	×	×												Purple fruit
do			×	×											
do			×												
do	×							×							Purple fruit
Rather large	×	×													Pinkish fruits
Fleshy aril					×	×	×								Rare
do		×	×												
Fleshy		×													Brilliant fruits
do		×	×												
do			×	×	×	×									
Spongy do	×														Acid, insect-eaten
Spongy do			×	×						×					do rare

Eaten by many kinds of birds.

Orders		Genus	Species
No. 60 **Datiscaceae.**	No endemics		
61 **Cactaceae.**	do		
62 **Ficoideae.**	do		
63 **Umbellifereae.**		*Peucedanum*	*zeylanicum*
		Heracleum	*zeylanicum*
64 **Araliaceae.**		*Heptapleurum*	*emarginatum*
65 **Cornaceae.**		*Alangium*	*glandulosum*
		Mastixia	*tetrandra*
66 **Caprifoliaceae.**	No endemics		
67 **Rubiaceae.**		*Nauclea*	*zeylanica*
		Neurocalyx	*zeylanicus*
			Gardneri
			Championii
		Alloeophania	*decipiens*
		Hedyotis	*evenia*
			eymosa
			Macraei
			obscura
			coprosmoides
			membranacea
			Thwaitesii

Fruit	Western							Eastern							Remarks
	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	
Minute							×								Very rare
do						×									
Small, pulpy		×	×	×											
Fleshy		×	×	×	×	×									Coloured fruit
do		×	×	×											
Massed		×	×	×						×					Rare
Dry	×	×	×	×	×										
	×														Very rare
	×	×													
Small capsule			×	×	×	×	×								
Small					×	×									Very rare
Minute	×														Very rare
															Material wanted
do					×	×	×					×			
do						×	×								
?	×														
Minute	×	×	×	×	×	×									Rare

Orders	Genus	Species
No. 67 Rubiaceae. (*Contd.*)	*Hedyotis*	*nodulosa*
		cinereo-viridis
		rhinophylla
		Lessertiana
		quinquenervia
		Gardneri
		Lawsoniae
		inamoena
		cyanescens
	Anotis	*numularia*
		numulariformis
		Richardiana
	Ophiorrhiza	*radicans*
		pallida
		glechomifolia
	Acranthera	*zeylanica*
	LEUCOCODON	*reticulatum*
	Urophyllum	*ellipticum*
		zeylanicum
	SCHIZOSTIGMA	*hirsutum*
	Byrsophyllum	*ellipticum*

Fruit	Western							Eastern							Remarks
	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	
Minute				×	×	×									
?								×							Rare
Capsule											×				Very rare
do				×	×										
do						×									Very rare
do					×										Rare
do				×	×										
do		×													Very rare
do	×														Very rare
do			×	×	×										
do					×										
do					×	×									
do	×	×	×												
do		×													Very rare
do	×	×	×												
Fleshy		×	×	×							×	×			
do			×	×	×										
do	×	×	×	×	×	×									
do					×	×	×	×							
do	×	×													In very wet (rain) localities
Berry	×														Very rare

Orders	Genus	Species
No.67 **Rubiaceae.** (*Contd.*)	*Randia*	*Gardneri*
	NARGEDIA	*macrocarpa*
	SCYPHOSTACHYS	*pedunculata*
		coffaeoides
	Diplospora	*Dalzellii*
		erythrospora
	Dichilanthe	*zeylanica*
	Knoxia	*zeylanica*
		platycarpa
	Canthium	*montanum*
		puberulum
		macrocarpum
		campanulatum
	Ixora	*calycina*
		Thwaitesii
		jucunda
	Pavetta	*angustifolia*
		Gleniei
		involucrata
	Psychotria	*stenophylla*
		glandulifera

Fruit	Western							Eastern							Remarks
	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	
Fleshy	×	×													
Berry	×	×													Very rare
do	×														Very rare
do	×														Rare
do															
do				×	×										Very rare
?			×												Very rare
Dry	×	×													In waste and open spaces
do					×	×									In patina lands
Drupe				×	×	×	×								
															Material wanted
do			×												Very rare
do		×	×							×					Very rare
Ovoid				×	×	×	×								
Globose	×	×													
do	×	×	×												
do	×														Water-loving
do	×							×							
					×	×									
Fleshy	×	×													Bright purple fruits
do						×									

Orders	Genus	Species
No.67 **Rubiaceae.** *(Contd.)*	*Psychotria*	*Gardneri*
		Wrightiana
		Mooniana
		sordida
		longipetiolata
		plurivenia
		filipes
	Lasianthus	*Moonii*
		Thwaitesii
		rhinophyllus
		Walkerianus
		Gardneri
		oliganthus
		obliquus
		strigosus
		varians
	Saprosma	*scabridus*
68 **Valerianaceae.**	*Valeriana*	*Moonii*
69 **Dipsacaceae.**	*Dipsacus*	*Walkeri*
70 **Compositae.**	*Vernonia*	*Gardneri*
		Thwaitesii

Fruit	Western							Eastern							Remarks
	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	
Fleshy															
do	×														Water-loving
do	×														Rare
do					×	×									
do				×	×										Very rare
do			×	×											Very rare
do		×	×	×											Rare
Berry	×	×	×												
do			×												Very rare
?			×			×									Very rare
Berry	×	×	×	×											Water-loving
do				×	×	×									
Small berry	×	×	×												
Berry	×	×	×												
do	×	×	×	×						×	×	×			
do					×	×	×								
do	×														Rare. Material wanted
Dry					×	×									
Achene				×	×	×									
Dry			×	×	×	×									Wind-carried seeds
do					×	×									Very rare

Orders		Genus	Species
No.70 **Compositae.** (*Contd.*)		*Vernonia*	*anceps*
			setigera
			Hookeriana
			scariosa
			nemoralis
			Wightiana
			zeylanica
		Blumea	*crinita*
			angustifolia
		Anaphalis	*pelliculata*
			fruticosa
			Thwaitesii
			zeylanica
		Gynura	*zeylanica*
			hispida
		Emilia	*zeylanica*
		Senecio	*Gardneri*
71 **Stylidiaceae.**	No endemics		
72 **Gordenoviaceae.**	do		
73 **Campanulaceae.**	do		
74 **Vacciniaceae.**	do		

Fruit	Western							Eastern							Remarks
	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	
Dry															Rare
do															
do															Common in patinas
do															
do															Water-loving
do															
do															
do															Seed wind-carried
do															Water-loving. Very rare
do															Very rare
do															Very rare
do															Very rare
do															In patinas
do															
do															In patinas
do															
do															Very rare

Orders			Genus	Species
No.75	**Ericaceae.**	No. endemics		
76	**Plumbaginaceae.**	do		
77	**Primulaceae.**	do		
78	**Myrsinaceae.**		*Ardisia*	*Willisii*
				polylipis
				Moonii
79	**Sapotaceae.**		*Bassia*	*Moonii*
				neriifolia
				microphylla
				fulva
			Palaquium	*petiolare*
				grande
				rubiginosum
				caniculatum
				Thwaitesii
				laevifolium
				pauciflorum
80	**Ebenaceae.**		*Maba*	*acuminata*
				ovalifolia
				oblongifolia
			Diospyros	*attenuata*

Fruit	Western							Eastern							Remarks
	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	
?	×														
Pulpy															Locality ?
do	×	×													Red fruits
Fleshy	×														Very rare
do	×	×													Water-loving
do	×														
do	×														
do	×	×													Sub-gregarious
do	×	×	×	×	×										Water-loving
do			×	×	×	×				×	×				
do	×														Very rare
do	×														Very rare
do	×	×													
do	×														Rare
do	×														Very rare
do	×														Very rare
do	×														
do	×														Very rare

Orders	Genus	Species
No.80 **Ebenaceae.** (*Contd.*)	*Diospyros*	*acuta*
		Gardneri
		quaesita
		hirsuta
		oppositifolia
		Thwaitesii
		Moonii
81 **Styraceae.**	*Symplocos*	*laeta*
		bractealis
		versicolor
		acuta
		cuneata
		hispidula
		Walkeri
		jucunda
		angustifolia
		latiflora
		elegans
		minor
		hebantha
		cordifolia

Fruit	Western							Eastern							Remarks
	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	
Fleshy	×														Very rare
do	×	×													
do	×	×													Becoming very scarce
do	×														Water-loving
do	×														Very rare
do	×														
do	×														In damp swampy lands
Fleshy drupe				×	×	×	×				×	×	×		
do						×	×								
do	×	×													Very rare
do		×													Very rare
do	×	×													
do			×	×	×	×									Rare
? do															Locality wanted
do	×	×	×												
? do					×	×						×			Very rare
do				×	×	×					×	×	×		
do					×	×	×					×	×		
do					×	×	×								
? do				×											Very rare
do						×	×							×	Rare

Orders		Genus	Species
No.81 **Styraceae.** (*Contd.*)		*Symplocos*	*apicalis*
			marginalis
			coronata
82 **Oleaceae.**		*Linociera*	*purpurea*
83 **Salvadoraceae.**	No endemics		
84 **Apocynaceae.**		*Willughbeia*	*zeylanica*
		Alyxia	*zeylanica*
		Holarrhena	*mitis*
		Wrightia	*flavido-rosea*
			angustifolia
			zeylanica
		Baissea	*acuminata*
		Anodendron	*rhinosporum*
85 **Asclepiadaceae.**		*Gymnema*	*rotundatum*
		Tylophora	*membranifolia*
			cordifolia
			flava
		Ceropegia	*Gardneri*
			parviflora
		Caralluma	*campanulata*
86 **Loganiaceae.**		*Strychnos*	*micrantha*

Fruit	Western						Eastern							Remarks
	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	
Fleshy drupe	×													Rare
do		×												Rare
do	×	×	×	×				×						
Hard drupe	×						×							
Fleshy	×	×	×											Monkey-eaten fruits
Pulpy	×													Scarlet fruit
Pod	×						×							Wind-carried seed
do							×							Wind-carried seed
do							×							Wind-carried seed
do	×													Wind-carried seed
do		×	×	×	×	×								Wind-carried seed
do			×						×					Rare
Comose seed							×	×						Rare
do	×						×							
do		×	×	×					×	×				
do	×													
do				×	×									Very rare
do							×							Very rare (?)
Winged and comose		×	×											Doubtfully endemic
Pulpy berry	×	×					×							

Orders		Genus	Species
No.86	**Loganiaceae.** (*Contd.*)	*Strychnos*	*Benthami*
			cinnamomifolia
		Gaertnera	*rosea*
			Walkeri
			ternifolia
87	**Gentianaceae.**	*Exacum*	*axillare*
			Walkeri
			zeylanicum
			macranthum
		Swertia	*zeylanica*
88	**Hydrophyllaceae.**	No endemics	
89	**Boraginaceae.**	*Cordia*	*oblongifolia*
		Tournefortia	*Walkerae*
90	**Convolvulaceae.**	*Argyreia*	*populifolia*
		Lettsomia	*hancorniaefolia*
		Ipomaea	*jucunda*
91	**Solanaceae.**	No endemics	
92	**Ssrophulariaceae.**	*Adenosma*	*subrepens*
			camphoratum
93	**Orobanchaceae.**	*Christisonia*	*Thwaitesii*
			tricolor

Fruit	Western							Eastern							Remarks
	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	
Pulpy berry															
do	×	×	×												
do	×	×													Purple fruit. Rare
do			×	×	×	×	×								Dark blue fruit
do					×	×									Blue fruit
Capsule	×														Rare
do					×	×	×								
do	×	×	×	×											
do					×	×	×								In patinas
do						×	×								In patinas
Drupe	×	×													
do	×	×						×							
Dry	×	×	×	×				×							
do		×													Very rare
Hairy			×												Very rare
Capsule	×														Wet ground. Very rare
do	×														
do			×	×											Very rare
do			×	×	×										

Orders		Genus	Species
No.93	**Orobanchaceae.** (*Contd.*)	*Christisonia*	*albida*
94	**Lentibulariaceae.** No endemics		
95	**Gesneraceae.**	*Didymocarpus*	*Humboldtianus*
			floccosus
			zeylanicus
		Chirita	*Moonii*
			Walkeri
			zeylanica
		CHAMPIONIA	*reticulata*
		Klugia	*zeylanica*
96	**Bignoniaceae.** No endemics		
97	**Pedaliaceae.** do		
98	**Acanthaceae.**	*Cardanthera*	*Thwaitesii*
		Strobilanthes	*viscosus*
			Nockii
			stenodon
			exareolatus
			rhytispermus
			nigrescens
			rhamnifolius
			deflexus

Fruit	Western							Eastern							Remarks
	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	
Capsule															Very rare
Dry capsule	×	×	×	×	×			×	×	×	×				
do		×													Very rare
do					×	×									
do		×	×												
do	×	×	×	×	×	×	×								
do	×	×	×	×											
do	×	×	×	×											Rare
do	×	×													Water-loving
Capsule								×							Rare
do				×	×	×	×								Gregarious
do						×									Very rare
do										×	×				Very rare
do										×					Rare
do															Material wanted
do				×											Very rare
do				×											Rare
do	×	×	×												

Orders	Genus	Species
No.96 **Acanthaceae.** (*Contd.*)	*Strobilanthes*	*lanceolatus*
		Walkeri
		Thwaitesii
		punctatus
		Arnottianus
		asperrimus
		trifidus
		exsertus
		Gardnerianus
		vestitus
		Hookeri
		calycinus
		laxus
		zeylanicus
		helicoides
		paniculatus
		pulcherrimus
	Barleria	*vestita*
		nutans
	Gymnostachyum	*zeylanicum*
		Thwaitesii

Fruit	Western							Eastern							Remarks
	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	
Capsule															
do															
do															Very rare
do															Very rare
do															
do															Gregarious
do															Doubtful sp.
do															
do															Very rare
do															Gregarious
do															Gregarious
do															Gregarious
do															
do															Very rare
do															
do															Rare
do															
do															Rare
do															Rare
do															
do															Very rare

Orders	Genus	Species
No.98 **Acanthaceae.** (*Contd.*)	*Gymnostachyum*	*paniculatum*
		sanguinolentum
		hirsutum
	Lepidagathis	*zeylanica*
		Walkeriana
	Justicia	*zeylanica*
		Hookeriana
		Royeniana
	PTYSSIGLOTTIS	*radicosa*
99 **Verbenaceae.**	*Premna*	*purpurascens*
		Thwaitesii
	Glossocarya	*scandens*
100 **Labiatae.**	*Plectranthus*	*nigrescens*
		Gardneri
		capillipes
	Coleus	*inflatus*
		elongatus
	Anisochilus	*velutinus*
	Pogostemon	***rupestris***
		hirsutus
		reflexus

Fruit	Western							Eastern							Remarks
	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	
Capsule	×	×													
do	×	×	×												
do			×	×											Rare
do	×	×	×												
do	×	×	×												
do	×	×													Rare
do	×	×	×												Water-loving
do			×	×	×	×					×				
do		×													On wet rocks
Drupe	×	×													Very rare, ? endemic
do									×	×	×				Rare
Capsular	×							×							
Achene					×	×	×								
do						×	×						×		
do			×	×	×										
do					×	×									
do									×	×	×				Very rare
do								×	×	×	×				
do				×	×	×	×								
do				×	×	×	×								
do			×	×	×	×	×								

Orders		Genus	Species
No.100	**Labiatae.** (*Contd.*)	*Scutellaria*	*oblonga*
101	**Plantaginaceae.** No endemics		
102	**Nyctaginaceae.** do		
103	**Amarantaceae.**	*Cyathula*	*zeylanica*
		Psilotrichum	*scleranthum*
		Achyranthes	*diandra*
104	**Chenopodiaceae.** No endemics		
105	**Polygonaceae.** do		
106	**Podostemaceae.**	*Dicrea*	*elongata*
		Farmeria	*metzgerioides*
107	**Nepenthaceae.**	*Nepenthes*	*distillatoria*
108	**Aristolochiaceae.** No endemics		
109	**Piperaceae.**	*Piper*	*Thwaitesii*
			zeylanicum
			trineuron
		Peperomia	*pseudo-rhombia*
			confusa
110	**Chloranthaceae.** No endemics		
111	**Myristicaceae.**	*Myristica*	*zeylanica*
			Horsfieldia
112	**Monimiaceae.**	HORTONIA	*floribunda*

Fruit	Western							Eastern							Remarks
	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	
Achene	×	×	×	×	×	×	×				×	×	×		Water-loving
Dry, thin								×							Very rare
Membranous															
															Locality wanted
Capsule	×	×													In rivers
do		×													Riverine
do	×	×						×							In wet soils
Globose, pulpy					×	×									Red fruit
do					×	×									
do	×	×	×	×											
Dry												×			On moist rocks
do															On trees
Fleshy								×	×	×					Rare. Coloured aril
do	×														Coloured aril
Pulpy															

Orders	Genus	Species
No.112 **Monimiaceae.** (*Contd.*)	HORTONIA	*angustifolia*
113 **Lauraceae.**	*Cryptocarya*	*membranacea*
	Beilschmiedia	*zeylanica*
	Cinnamomum	*multiflorum*
		ovalifolium
		litseaefolium
		citriodorum
	Actinodaphne	*molochina*
		stenophylla
		elegans
		glauca
		pisifera
		ambigua
		speciosa
	Litsea	*undulata*
		cauliflora
		Hookeriana
		nemoralis
		ovalifolia
		glaberrinia
		iteodaphne

Frui.	Western							Eastern							Remarks
	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	
Pulpy	×	×													By streams
Ovoid	×														Purple fruits
do			×	×											Purple fruits
do					×										
do					×	×	×					×			
?					×										Very rare
Ovoid	×														Dark purple fruit. Very rare
Globose						×	×								
do	×	×	×	×					×	×					Purple fruit. In patinas
Fleshy	×	×	×												Red fruits
Minute							×								Rare
?						×	×					×			Rare
Ovoid				×	×	×					×	×			Rare
do					×	×	×								
Globose	×	×													Rare
do	×	×	×												
?															Material wanted
Ovoid	×														Very rare
do		×	×	×	×	×	×				×	×	×		Purple fruits
Globose				×	×	×	×					×	×		Dark purple fruits
Ovoid				×	×	×									Purplish-red fruits

Orders		Genus	Species
No.113 **Lauraceae.** (*Contd.*)		*Litsea*	*Gardneri*
			fuscata
		Lindera	*lancifolia*
114 **Proteaceae.**		*Helicia*	*zeylanica*
115 **Thymelaeaceae.**		*Phaleria*	*cauliflora*
		Gyrinops	*Walla*
116 **Elaeagnaceae.**	No endemics		
117 **Loranthaceae.**		*Loranthus*	*nodiflorus*
			mabaeoides
			ensifolius
			sclerophyllus
			ligulatus
			suborbicularis
			lonchiphyllus
			Gardneri
		Notothixos	*floccosus*
		Ginalloa	*spathulifolia*
118 **Santalaceae.**	No endemics		
119 **Balanophoraceae.**		*Balanophora*	*Thwaitesii*
120 **Euphorbiaceae.**		*Bridelia*	*Moonii*
		Cleistanthus	*acuminatus*

Fruit	Western							Eastern							Remarks
	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	
Ovoid															
Globose															
Ovoid												×			Material wanted
do		×	×	×						×					Purplish fruit
Fleshy	×														Crimson fruit. Rare
Capsule	×	×	×	×											
Berry	×	×													
do									×	×					Very rare
do	×														
do					×	×	×								
do	×							×							Rare
do						×	×								Crimson fruit
do			×												Red fruit. Very rare
do	×	×													Red fruit. Very rare
Ovoid do	×														Yellowish fruit
do		×				×									Very rare
?				×	×	×									Rare
Drupe		×						×							
Capsule	×														

Orders	Genus	Speceis
No.120 **Euphorbiaceae.** (*Contd.*)	*Cleistanthus*	*robustus*
		pallidus
		ferrugineus
	Sauropus	*retroversus*
		assimilis
		rigidus
	Phyllanthus	*Thwaitesianus*
		myrtifolius
		Baillonianus
		anabaptizatus
		oreophilus
		hakgalensis
		cinerens
		affinis
		cyanospermum
	Glochidion	*brachylobum*
		pycnocarpum
		rigidum
		coriaceum
		nemorale
		Gardneri

Fruit	Western							Eastern							Remarks
	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	
Capsule	·														Rare
do	×		·					·	·						
do	×	×	×												
Fleshy			·			·								·	Very rare
do			×												Very rare
do								×	×						Rare
Dry capsule								×							
Small		×						×	×						Water-side. Rare
Globose	×	×	×							×					
Small					·										Water-loving. Very rare
do								×					×		
do							×								Very rare
do				·							×				
do							×								Very rare
do	×														Blue arillus
Succulent			×												
?										×					
Small	×	×	×						×						
do				×	×	×									
do	×														Very rare
do	×														Red cocci

Orders	Genus	Species
No.120 **Euphorbiaceae.** (*Contd.*)	*Glochidion*	*monanum*
		Moonii
	Putranjiva	*zeylanica*
	Hemicyclia	*lanceolata*
		Gardneri
	Aporosa	*latifolia*
		lanceolata
		fusiformis
	Antidesma	*pyrifolium*
	Croton	*Moonii*
		nigro-viridis
	Trigonostemon	*diplopetalus*
	Agrostistachys	*Hookeri*
	Adenochlaena	*zeylanica*
	PODADINA	*sapida*
	Claoxylon	*oligrandum*
	Mallotus	*eriocarpus*
		Walkerae
		fuscescens
	Macaranga	*digyna*
	Chaetocarpus	*pubescens*

Fruit	Western						Eastern						Remarks
	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	
Small			×						×	×			Rare
do	×												
Drupe		×											Very rare
do													Very rare
Pulpy, drupe	×						×	×					
Pulpy	×												
do	×	×											Yellowish fruits
do				×	×	×							
Juicy	×	×	×	×				×	×	×			
Globose	×												Very rare
Woody			×	×	×				×	×			
Fleshy	×												Very rare
Globose	×												Near water
Small			×	×	×								
Fleshy	×												Red fruit. Very rare
Small		×	×	×					×				
Globose							×						
Capsule	×	×	×				×	×	×				
do	×	×											
	×												Rare. In wet places
Capsule	×												Very rare

Orders		Genus	Species
No.120	**Euphorbiaceae.** (*Contd.*)	*Chaetocarpus*	*coriaceus*
121	**Urticaceae.**	*Ficus*	*candiculata*
			Mooniana
			Thwaitesii
		Artocarpus	*nobilis*
		Allaeanthus	*zeylanicus*
		Elatostema	*Walkerae*
		Pouzolzia	*Walkeriana*
		Debregeasia	*zeylanica*
122	**Ceratophyllaceae.**	No endemics	
123	**Cycadaceae.**	do	
124	**Hydrocharitaceae.**	*Blyxa*	*zeylanica*
125	**Burmanniaceae.**	*Burmannia*	*Championii*
		Thisma	*Gardneriana*
126	**Orchidaceae.**	*Oberonia*	*truncata*
			Thwaitesii
			longibracteata
			zeylanica
			tenuis
			forcipata

Fruit	Western							Eastern							Remarks
	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	
Capsule	×														
Fleshy	×														Very rare
do	×	×	×												Red fruits
do	×	×	×	×					×	×					
do	×	×							×						
do	×								×						
do				×											Very rare
Small	×														
Fleshy	×	×													
	×							×							Water-carried
	×	×													A saprophyte
		×													Very rare
$\frac{1}{10}$ inch			×	×											
Minute	×														Very rare
$\frac{1}{10}$ inch				×	×	×									
$\frac{1}{8}$ inch						×						×			Rare
$\frac{1}{10}$ inch	×														Very rare
$\frac{1}{10}$ inch		×	×	×											

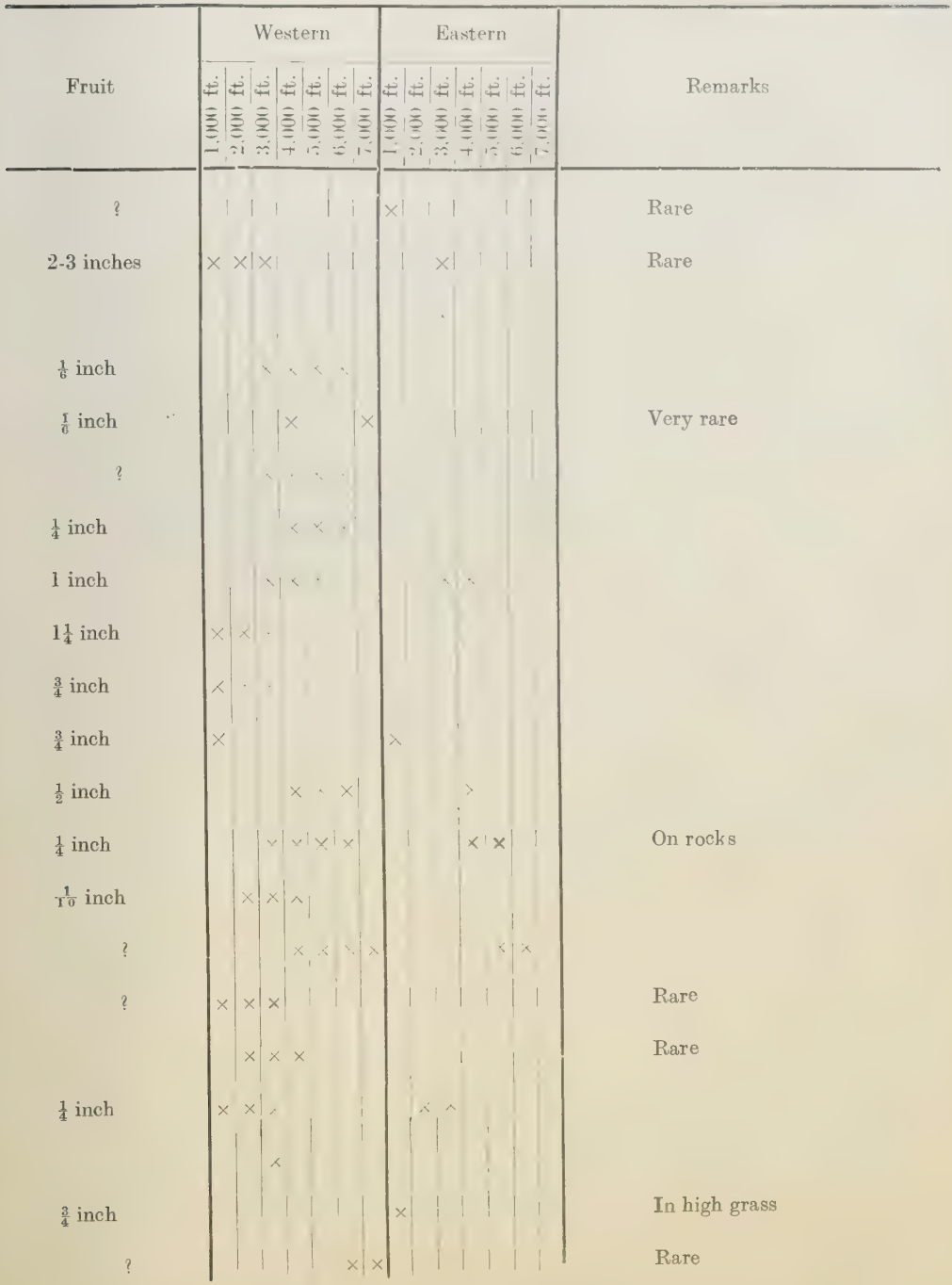
Orders	Genus	Species
No.126 **Orchidaceae.** (*Contd.*)	*Oberonia*	*scyllae*
	Microstylis	*purpurea*
		discolor
		lancifolia
	Liparis	*Thwaitesii*
		Trimenii
		barbata
		brachyglottis
		obscura
	Dendrobium	*panduratum*
		diodon
		Macarthiiae
	Bulbophyllum	*crassifolium*
		petiolare
		purpureum
		elegans
		sp. nov.
	Cirrhopetalum	*grandiflorum*
		Wightii
		Trimenii
		Macraei

Fruit	Western							Eastern							Remarks
	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	
?				×	×	×					×				
⅔ inch	×														Near water, very rare
⅓ inch	×	×	×	×	×	×									
do	×	×													Near water
?	×														Very rare
¼ inch				×											Very rare
?															Material wanted
												×			Very rare
		×	×	×							×				
			×	×	×	×									
¼ inch					×	×						×			
Large	×	×													In wet forests
Ovoid		×													Very rare
⅓ inch	×	×													
		×	×							×					
Ellipsoid			×	×	×	×									
?											×				Rare
1½ inches			×	×	×	×									
		×		×	×	×	×								
						≺									
			×	×	×										

Orders	Genus	Species
No. 126 **Orchidaceae.** (*Contd.*)	*Cirrhopetalum*	*Thwaitesii*
	Coelogyne	*brevicuspa*
		zeylanica
	ADRORHIZON	*purpurascens*
	Chrsoglossum	*maculatum*
	Acanthophippum	*bicolor*
	Eria	*baccata*
		bicolor
		tricolor
		Lindleyi
		Thwaitesii
	ALVISIA	*tenuis*
	Arundina	*minor*
	Agrostophyllum	*zeylanicum*
	Ipsea	*speciosa*
	Phajus	*Wallichii*
		luridus
	Calanthe	*purpurea*
	Polystachya	*zeylanica*
	Sarcochilus	*viridiflorus*
		pulchellus

Fruit	Western							Eastern							Remarks
	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	
$\frac{2}{3}$ inch				×	×	×	×								
$1\frac{1}{4}$ inches					×	×									
		×													
$\frac{3}{4}$ inch				×	×	×	×								
$1\frac{1}{4}$ inches				×	×										Rare
	×														
$\frac{1}{2}$ inch				×	×	×	×								
					×	×									
				×	×										
							×								
$\frac{1}{2}$ inch		×	×	×	×	×									
	×														
1 inch	×	×	×	×											
					×	×									
			×	×	×	×									In patinas
2 inches			×	×	×	×	×								In open places
2 inches	×	×													Rare
$1\frac{1}{2}$ inches	×	×	×												
$\frac{1}{2}$ inch	×	×	×	×						×					
$1\frac{1}{2}$ inches						×									Very rare
2-3 inches	×	×													

Orders	Genus	Species
No. 126 **Orchidaceae.** (*Contd.*)	*Sarcochilus*	*pugionifolius*
		complanatus
	Vanda	*Thwaitesii*
	Saccolabium	*niveum*
		gracile
		brevifolium
		roseum
		acaule
	Cleisostoma	*maculosum*
		decipiens
	Mystacidium	*zeylanicum*
	Taeniophyllum	*Alwisii*
	Podochilus	*falcatus*
		saxatilis
	OCTARRHENA	*parvula*
	Hetaeria	*Gardneri*
	Cheirostylis	*parvifolia*
	Anaectochilus	*regalis*
	Zeuxine	*regia*
	Tropidia	*Thwaitesii*
		bambusifolia


Fruit
Western
Eastern
1,000 ft.
2,000 ft.
3,000 ft.
4,000 ft.
5,000 ft.
6,000 ft.
7,000 ft.
Remarks
?
Rare
2-3 inches
Rare
1/6 inch
1/6 inch
Very rare
?
1/4 inch
1 inch
1 1/4 inch
3/4 inch
3/4 inch
1/2 inch
1/4 inch
On rocks
1 1/0 inch
?
?
Rare
Rare
1/4 inch
3/4 inch
In high grass
?
Rare

Orders	Genus	Species
No. 126 **Orchidaceae.** (*Contd*).	*Vanilla*	*Moonii*
	Habenaria	*acuminata*
		dolichostachya
		dichopetala
		pterocarpa
		rhyncocarpa
		breviloba
		Trimeni
		Gardneri
127 **Scitamineae.**	*Curcuma*	*oligantha*
		albiflora
	Alpinia	*rufescens*
	Amomum	*floribundum*
		involucratum
		nemorale
		acuminatum
		fulceps
		masticatorum
		graminifolium
		ciliatum
		pterocarpum

Fruit	Western							Eastern							Remarks
	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	
4 inches															
Capsular															Terrestial
do															Rare
do															
															Rare. Near water
1 inch															
?															Rare
?															
?															
Membranous															
?															Very rare
?															Very rare
															Rare
Ovoid															
do															Rare
?															Very rare
Globose															
?															
?															Very rare
Fleshy															

	Orders		Genus	Species
No.127	**Scitamineae.** (*Contd.*)		*Amomum*	*echinatumm*
				Benthamianum
			Zingiber	*cylindricum*
			CYPHOSTIGMA	*pulchellum*
			Phrynium	*zeylanicum*
128	**Haemodoraceae.**	No endemics		
129	**Amaryllidaceae.**	do		
130	**Taccaceae.**	do		
131	**Dioscoreaceae.**		*Dioscorea*	*intermedia*
132	**Roxburghiaceae.**	No endemics		
133	**Liliaceae.**		*Asparagus*	*zeylanicus*
			Urginea	*rupicola*
134	**Pontederiaceae.**	No endemics		
135	**Xyridaceae.**			
136	**Commelinaceae.**		*Commelina*	*Thwaitesii*
			Cyanotis	*obtusa*
				zeylanica
137	**Flagellariaceae.**	No endemics		
138	**Juncaceae.**	do		
139	**Palmaceae.**		*Areca*	*concinna*
			LOXOCOCCUS	*rupicola*

Fruit	Western							Eastern							Remarks
	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	
Fleshy	×	×	×	×											Fruits with hooked spines
Ovoid	×														Spined fruit. Very rare
Spongy, fleshy	×	×	×	×					×	×					
Fleshy	×	×	×	×	×										
Oblong	×								×						Fleshy aril. Rare
Capsule	×	×	×						×	×					
Berry		×	×	×	×	×	×			×	×	×			
Capsule	×							×							Very rare
do											×				Rare
1/16 in. do									×						Very rare
1/6 in. do					×					×	×				
Ovoid	¼														In flooded areas
¾ in. do			×	×	×						×	×			In rocky places

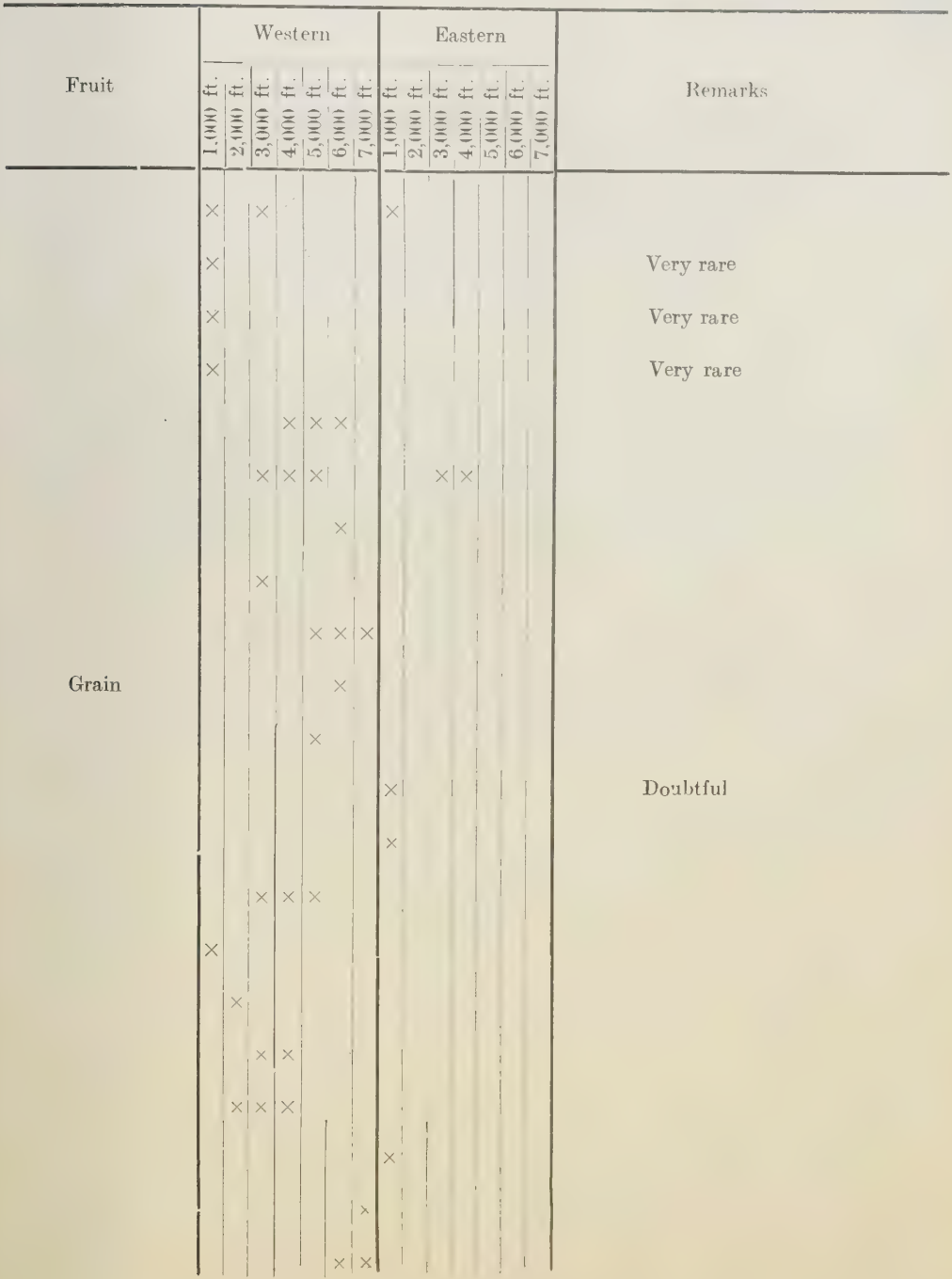
Orders		Genus	Species
No.139 **Palmaceae.** (*Contd.*)		*Oncosperma*	*fasciculatum*
		Phoenix	*zeylanica*
		Calamus	*rivalis*
			delicatulus
			radiatus
			pachystemonus
			digitatus
			zeylanicus
			ovoideus
140 **Pandanaceae.**		*Pandanus*	*zeylanicus*
		Freycinetia	*pycnophylla*
			Walkeri
141 **Typhaceae.**	No endemics		
142 **Araceae.**		*Cryptocoryne*	*Thwaitesii*
			Nevillii
			Walkeri
			Beckettii
		Lagenandra	*Thwaitesii*
			lancifolia
			Koenigii
			insignis

Fruit	Western							Eastern							Remarks
	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	
Globose	×	×	×	×	×				×	×	×				On shallow soil, on rocks
Ovate	×							×							
Ellipsoid	×														Rare. Coloured fruits
½ in., globose	×														
⅓ in. do.	×														Yellow fruit
?	×														Rare
⅓ in. globose	×														Pale yellow fruits
¾ in. ,,	×	×													Yellowish brown fruit
Ovoid	×	×													Yellowish grey fruit
Globose	×														Water-loving
	×	×							×						Brilliant red fruit
	×	×	×	×	×										
Syncarp	×														Very rare
								×							Very rare. In marshes
?															Material wanted
?									×	×					Rare
Syncarp	×														Rare
	×														Water-loving
	×														Wet soil
	×														Very rare

Orders		Genus	Species
No.142	**Araceae.** *(Contd.)*	*Arisaema*	*filicaudatum*
		Theriophorum	*crenatum*
		Amorphophallus	*dubius*
		Pothos	*zeylanicus*
			Hookeri
			remotiflorus
143	**Lemnaceae.**	No endemics	
144	**Triuridaceae.**	*Sciaphila*	*erubescens*
			secundiflora
145	**Alismaceae.**	No endemics	
146	**Naiadaceae.**	*Aponogeton*	*crispum*
147	**Eriocaulonaceae.**	*Eriocaulon*	*caulescens*
			zeylanicum
			longicuspis
			atratum
			Trimeni
			Walkeri
			fluviatile
148	**Cyperaceae.**	*Cyperus*	*Nov. sp. (from Ritigala)*
		Fimbristylis	*aestivalis*
			Trimeni

Fruit	Western							Eastern							Remarks
	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	
Berry		×													Very rare
do	×							×							In grassy places
do	×	×													
do															Material wanted
do	×	×							×						
(?) do	×	×	×	×					×	×					
11/60in. soft	×														Very rare
Soft	×														Very rare
	×	×	×	×	×	×	×	×	×	×	×	×	×		Water plant. Doubtfully endemic
Capsule					×	×	×								Very rare
						×	×								
				×											Very rare
					×	×	×								
								×							
	×							×							Very rare
	×														In running water
										×					
	×														
	×														

Orders	Genus	Species
No.148 **Cyperaceae.** (*Contd.*)	*Fimbristylis*	*fulvescens*
	Hypolytrum	*longirostre*
	Mapania	*immersa*
	Scleria	*junciformis*
	Carex	*Arnottiana*
		spicigera
		zeylanica
		brevicuspa
		lobulirostris
149 **Gramineae.**	*Isachne*	*elatior*
		multiflora
	Panicum	*sparsicomum*
	Oplismenus	*Thwaitesii*
	Arundinella	*laxiflora*
		blephariphylla
		Thwaitesii
	Leptaspis	*cochleata*
	Dimeria	*pubescens*
		Thwaitesii
		Trimeni
	Pollinia	*Thwaitesii*


Fruit
Western
Eastern
1,000 ft.
2,000 ft.
3,000 ft.
4,000 ft.
5,000 ft.
6,000 ft.
7,000 ft.
Remarks
Very rare
Very rare
Very rare
Grain
Doubtful

Orders	Genus	Species
No.149 **Gramineae.** (*Contd.*)	*Rottboellia*	*nigrescens*
	Ischaemum	*rivale*
	Eremochloa	*zeylanica*
	Cymbopogon	*Thwaitesii*
	Garnotia	*Thwaitesii*
		tectorum
		fuscata
		Fergusonii
		micrantha
		panicoides
	Zenkeria	*obtusiflora*
	Coelachne	*perpusilla*
	Eragrostis	*secunda*
		Walkeri
	Lophatherum	*zeylanicum*
	Arundinaria	*floribunda*
		debilis
	Teinostachyum	*attenuatum*
	Ochlandra	*stridula*

Fruit	Western							Eastern							Remarks
	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	1000, ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.	6,000 ft.	7,000 ft.	
															Localities wanted
	×														Localities wanted
					×										
				×	×										
			×	×											
	×														Material insuff.
	×														
					×		×								
					×										
					×			×							Imperfect
	×														
					×										
						×	×								
				×	×	×									
	×	×													

It is hoped that further verification both of species and distribution will in time be available in order to secure more complete data as to the exact distribution of Ceylon's endemic flora, but for the present it is hoped that even these imperfect details may be of some service to ecology.

REFERENCES

1. Brandis, D. Enumeration of the Dipterocarpaceae. Jour. Linn. Soc., Bot., XXXI. (1895).
2. Pearson, H. H. W. The botany of the Ceylon patanas. Jour. Linn. Soc., Bot., XXXIV., No. 238 (1899).
3. Wait, W. E. The Passerine birds of Ceylon. Spolia Zeylanica, XII., Part 45 (1922).
4. Willis, J. C. Studies in the morphology and ecology of the Podostemacea of Ceylon and India. Annals, R. B. G., Peradeniya, I., pp. 267-465 (1902).
5. Willis, J. C. Revised catalogue of the flowering plants and ferns of Ceylon. 1911.
6. Wright, H. The genus Diospyros in Ceylon. Annals, R. B. G., Peradeniya, I., Plate VI., fig. 5.

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Additions to Ceylon Fungi

IV. Basidiomycetae

BY

T. Petch, B.A., B.Sc.

Clitocybe corrugata Petch, n. sp. Pileus up to 6.5 cm. diameter; broadly convex, then plane, depressed in the centre, blackish brown or greyish brown, paler towards the margin, hygrophanous, with a cartilaginous cuticle which is puckered into radial and transverse ridges, strongly radially striate with dark lines over the gills when moist ; stalk up to 4 cm. high, 1 cm. diameter, equal, pallid, becoming grey when handled, longitudinally fibrillose, mealy at the apex, solid, internally greyish white, expanding into the pileus ; gills very distant, broad (11 mm.), ventricose, sinuate behind, adnato-decurrent, pallid, becoming fuscous when old, interstices strongly veined ; spores white, oval, 6-9 × 4 μ ; strong smell of meal. On the ground among grass, Peradeniya, July 29, 1909 ; October, 1914. Specimens and painting, No. 4202.

There is apparently a figure of this species included among the paintings assigned by Berkeley and Broome to *Collybia multijuga*. The figure shows a similar pileus, but a hollow stem. It is possible that the stem may have been hollowed out by insects.

Clitocybe flavescens Petch, n. sp. Yellowish or ochraceous in the centre, paler towards the margin, broadly convex, then almost plane, slightly depressed in the centre, smooth, up to 3 cm. diameter ; stalk white, faintly longitudinally fibrillose, flexuose, solid, expanding into the pileus, up to 2.5 cm. high, 3.5 mm. diameter ; gills pale yellow, distant, narrow, of three lengths, the longer arcuate, strongly decurrent, interstices veined ; spores globose, 4 μ diameter, with a few oval, 6-8 × 4 μ, white in mass. On the ground among grass, Peradeniya, October 16, 1914 ; specimen and painting, No. 4178.

Mycena farinosa Petch, n. sp. Pileus campanulate, up to 3.5.mm. diameter, white, feebly sulcate, strongly pruinose; stalk whitish, translucent, curved, attenuated upwards, tomentoso-pruinose, up to 5 mm. high, 0.4 mm. diameter, base slightly inflated, no disc ; gills ascending, narrow, distant, white ; spores white, ovoid, 7 × 5 μ, or globose 5 μ.

Pruina on the pileus consists of spherical or ovoid cells, 16-24 μ diameter, echinulate with close-set, short, acute spines, or verrucose, attached to the pileus by a short stalk. Similar cells occur on the stipe, together with others which are larger, ovoid, or sometimes lobed, up to 90 × 20 μ, with a stalk 10 μ long, 6 μ diameter. On the bark of a living jak tree, Peradeniya, November, 1919 ; No. 6145.

Mycena aculeifera Petch, n. sp. Pileus up to 4 mm. diameter, broadly convex, centre ultimately depressed, white, membranous, sparsely covered with conical processes, margin striate ; stalk up to 12 mm. high, 0.5 mm. diameter, attenuated upwards, white, subtranslucent, minutely pruinose, becoming glabrous, arising from a circular fimbriate basal disc ; gills white, distant, narrow, lower edge straight, adnate, united behind over the stalk ; spores white, narrow-oval, 8 × 4 μ ; conical processes solid, up to 80 μ high, 50 μ diameter at the base, apex obtuse. On dead roots and rhizomes of Amomum, Peradeniya, December 17, 1914 ; specimen and painting, No. 4379.

When the fungus first begins to expand, the fimbriate edges of the basal disc form a cup ; the disc partly covers the pileus at first, *i.e.*, it represents a universal veil. This species is apparently included in the specimens assigned by Berkeley and Broome to *Mycena tenerrima*.

Mycena grisea Petch, n. sp. Pileus hemispherical, or broadly convex, or conico-campanulate, apex rounded, or in the larger specimens slightly obtusely umbonate, up to 2 cm. diameter, 1 cm. high, membranous, brownish grey or livid grey, with a central darker spot, glabrous, minutely hoary when dry, sulcate nearly to the centre, margin pale, recurved when old ; stalk up to 3.5 cm. high, 1.5 mm. diameter, equal, subtranslucent, blackish brown below, pallid above, with a few radiating fascicles of hairs at the base, hollow, sometimes exuding a clear liquid when broken ; gills white, then pallid, narrow, distant, attenuated outwards, edge straight, adnate with a decurrent tooth or line, interstices sometimes veined ; cystidia not found ; spores white, narrow-oval or oblong, 6-11 × 3-4 μ. On dead wood, decaying stumps, decaying fruits, Peradeniya ; type specimen and painting, No. 2885, July 16, 1909. Smell alkaline.

Mycena rorida Fr. Pileus up to 7 mm. diameter, hemispherical, or broadly convex, sometimes becoming plane, slightly depressed in the centre, white, pellucid, sprinkled with minute grey points, feebly radially striate ; stalk up to 2.8 cm. long, 0.75 mm. diameter, slightly attenuated upwards, white, subtranslucent, clothed with a thick layer of transparent gluten which tends to acumulate in the lower half, sometimes fuscous at the base, sometimes bulbous, sometimes with a narrow tuft of white fibrils ; gills white, of three lengths, distant, the longer

broad, arched, decurrent, edge toothed ; cystidia in groups, cylindric, 20 × 8 μ, or clavate, 16-24 μ high, 4 μ diameter below, expanding to 8-10 μ diameter above ; spores white, or faintly yellow, narrow-oval or clavate, 7-10 × 3-4 μ. On dead leaves and twigs, Peradeniya, October 19, 1914, etc., specimens and painting, No. 4188.

Coprinus macrorhizus (Pers.) Rea. On the ground, and on decaying palm nuts, Peradeniya, June 7, 1923 ; No. 6623.

Pileus at first conico-campanulate, obtuse, unexpanded pileus up to 1.3 cm. high, 1.5 cm. diameter, densely covered with fibrillose overlapping scales, dark grey, livid brown when the scales are removed ; becoming plane, 3 cm. diameter, bay brown in the centre, elsewhere sodden and blackish, very minutely pruinose, plicato-sulcate up to the bay brown centre. When expanded under a bell glass, the scales persist as floccose patches, and the margin may be recurved. Gills crowded, at first adnexed, becoming free, edge straight, outer end broadly rounded.

Stalk up to 12 cm. high, with a long rooting base, hollow, attenuated upwards, up to 5 mm. diameter below, 2 mm. diameter above, at first densely clothed with floccose, upwardly directed scales, becoming slightly floccose, or almost smooth, white. Spores dark brown by transmitted light, broadly oval or subglobose, sometimes slightly apiculate, 5-10 × 4-6 μ. Cystidia broadly pyriform, 50 × 30 μ.

This is *Coprinus macrorhizus* (Pers.) Rea, as figured by van Overeem, Icones Fungorum Malayensium, plate VI. Its spores are smaller than given by Rea for the European species.

Campanella purpureobrunnea Petch, n. sp. Orbicular, about 1 cm. diameter, sessile, convex, radially sulcate, sometimes reticulated, glabrous, subgelatinous, margin thin, blackish brown to purple brown, with the margin tending to lavender ; hymenium dark purple ; gills broad, distant, forked, radiating from beneath the point of attachment of the pileus, united by numerous cross septa ; basidia clavate, up to 18 μ long, 5 μ diameter, four-spored ; sterigmata slender, up to 4 μ long ; spores white in mass, globose, 3-4 μ diameter. On bark, Hakgala, April 20, 1919 ; No. 5988. Turns black when dry.

Laschia ? pezizaeformis B. & C. Sessile, circular, attached by a broad base, or orbicular with one-half reflexed, up to 3 mm. diameter, 1-1.5 mm. thick, subgelatinous, dorsal surface subreticulated, glabrous, greyish or brownish white, convex ; pores few, irregularly hexagonal or pentagonal, about 0.25 mm. diameter, pallid, pore surface plane ; spores white, broadly oval, 8 × 6 μ ; basidia broadly clavate, 15 × 6 μ, four-spored, sterigmata stout, cylindric, about 6 μ long ; cells of pileus

and on gills ovate, not crested. On dead wood, Hakgala, September, 1908 : No. 2995.

Hydnum fragile Petch, Ann. Perad., VII, p. 287 (1922).

This name is antedated by the well-known *Hydnum fragile* Fr. The species may be known as *Hydnum scabrum*.

PHYCOMYCETAE

Synchytrium fuscum Petch, n. sp. Galls minute, black, gregarious on the leaf, or clustered on swollen purple areas on the stem. Resting spores about three in each gall, solitary in the host tissue, dark brown, almost black, when fresh, yellow-brown in herbarium specimens, 85-100μ diameter, wall 8-12 μ thick, the inner wall 2-3 μ thick, contents at first yellow, dividing into hyaline, subglobose swarm spores, 3-4 μ diameter. On *Emilia sonchifolia*, Galboda, December, 1911; No. 3367.

PYRENOMYCETAE

Hyponectria Eugeniae Petch, n. sp. Hypophyllous, without evident spots ; perithecia gregarious, immersed subprominent, subconoid, up to 0.5 mm. diameter, 0.4 mm. high, orange red ; wall yellow ; asci cylindric, apex truncate and thickened, shortly pedicellate, 140-160 × 6 μ, spores uniseriate ; paraphyses numerous, linear, as long as the asci ; spores cymbiform, hyaline, continuous, ends rounded, 12-16 × 5 μ. On leaves of *Eugenia mabaeoides*, Hakgala, April, 1917 ;No. 5234.

Sphaerella rosigena Ell. and Ev. On Rosa cult., Peradeniya, October, 1919 ; No. 6127.

Trichosphaeria dactylosporifera Petch, n. sp. Perithecia scattered, superficial, globose, about 0.25 mm. diameter, black, not carbonaceous, sparsely clothed with spreading rigid conidiophores ; conidiophores up to 150 μ long, 6 μ diameter, septate, equal, sometimes geniculate above, brown, hyaline at the apex, bearing solitary, oval or broadly cymbiform, thick-walled conidia, muriform, not constricted, greenish olivaceous, then opaque, 18-20 × 12-15 μ ; asci broadly clavate or oval, sporse irregularly biseriate, 100 × 24-32 μ ; ascospores hyaline, oval inequilateral, or subcymbiform, ends obtuse, 22-32 × 12-14 μ. On a dead branch, Gangaruwa, December, 1913 ; No. 4108.

Trichosphaeria fasciculifera Petch, n. sp. Perithecia scattered, superficial, globose, 0.2-0.3 mm. diameter, black, not carbonaceous, with repent dark-brown hyphae spreading radially from the base over the substratum, clothed elsewhere with flexuose, dark-brown hyphae, 4 μ diameter, loosely united into erect, rigid, pointed fascicles, up to 0.4 mm.

long ; ostiolum not elevated ; asci about 90 × 12 μ, clavate, eight-spored, spores obliquely uniseriate ; spores hyaline, ellipsoidal, 12-16 × 6 μ, On dead stems of Lantana, Peradeniya, January 11, 1914 ; No. 3876.

Zignoella tuberculata Petch, n. sp. Perithecia superficial, clustered-ovoid, 0.2 mm. diameter, black, rugose with minute protuberances ; ostiolum minute, conical, scarcely evident ; wall leathery, not carbonaceous, parenchymatous, of rather large polygonal cells, 10-16 μ diameter ; asci broadly clavate, apex rounded, thick-walled, shortly pedicellate, eight-spored, spores biseriate, 136 × 24 μ ; paraphyses numerous, linear, as long as the ascus ; spores hyaline, fusoid, multiseptate, with up to eleven septa and containing numerous globules, 48-60 × 8-10 μ. On dead branches of *Mangifera indica*, Peradeniya, July 6, 1919 ; No. 6033.

Leptosphaeria depressa Petch, n. sp. Perithecia scattered, semi-immersed, depresso-globose, about 0.2 mm. diameter, black, not carbonaceous, ostiolum conical ; asci thick-walled, broadly clavate or ovoid, scarcely pedicellate, four or eight-spored, spores obliquely uniseriate or biseriate, 64-100 × 16-20 μ ; paraphyses stout ; spores narrow oval or cymbiform, rather thick-walled at first, three-septate, slightly constricted the septa, pale-brown, ends obtuse, 20-24 × 8 10 μ. On stems of *Camellia theifera*, Spring Valley, November , 1914 ; No. 4347.

Rhynchosphaeria sepulta Petch, n. sp. Perithecia immersed in the wood, black, globose, 0.25-0.3 mm. diameter, scattered, wall membranous, readily separating from the matrix, with a projecting, cylindrical ostiolum, up to 0.6 mm. long, 0.1 mm. diameter ; asci 54-60 × 8 μ, narrow clavate, with a short pedicel expanded at the base, eight-spored, spores biseriate above, uniseriate below ; paraphyses filiform, longer than the asci ; spores cylindric or subfusoid, ends obtuse, straight or slightly curved, three-septate, not or slightly constricted at the septa, brown, 10-13 × 4-5 μ. On dead stems of *Panax fruticosus*, Peradeniya, January, 1907 ; No. 2171.

Rosellinia caudata Petch, n. sp. Perithecia superficial, embedded at first in a dense purple-black subiculum which disappears with age, carbonaceous, black, becoming brown with a black apical area, glabrous, globose to subcylindric, rounded above, up to 1 mm. diameter, 1.25 mm. high, ostiolum conical, acute ; asci cylindric, shortly pedicellate, apex rounded and thickened, 200-220 × 12 μ, spores obliquely uniseriate ; spores dark brown, narrow oval, slightly inequilateral, ends obtuse, 24-30 × 8-9 μ, with a hyaline coat which is sometimes prolonged at one end into an appendage, 2 μ diameter, as long as the spore. On dead twigs of *Cinnamomum Camphora*, Hakgala, September, 1908 ; No. 2819,

Rosellinia tenuistromicola Petch, n. sp. Perithecia superficial, scattered, on a thin purple subiculum, carbonaceous, globose, black, minutely adpressed tomentose, 0.7-0.8 mm. diameter, ostiolum papillaeform, 0.05 mm. high ; asci, sporiferous part, 120 × 7 μ, spores uniseriate : spores cymbiform, blackish brown, ends acute or obtuse, 12-18 × 5-7 μ. On dead stems, Peradeniya, January, 1912 ; No. 3399.

Rosellinia obtusa Petch, n. sp. Perithecia erumpent, becoming superficial, scattered, carbonaceous, globose, 0.4 mm. diameter, black, smooth, ostiolum not elevated ; asci clavate, 100-110 × 8 μ, spores obliquely uniseriate above, uniseriate below ; spores oval or subcymbiform, ends obtuse, black-brown, 12-14 × 5 μ. On dead twigs of *Cinnamomum Camphora*, Hakgala, January, 1, 1914 ; No. 3878.

Rosellinia decidua Petch, n. sp. Perithecia erumpent, then almost superficial, gregarious, sometimes confluent, black, globose, minutely rough, up to 1.2 mm. diameter ; ostiolum minute, scarcely elevated, surrounded by a smooth, sometimes depressed ring ; wall up to 0.4 mm. thick, the outer layer scaling off when old and leaving a somewhat fleshy reddish wall ; asci cylindric, 100-120 × 5 μ, with a long tapering pedicel, spores uniseriate or slightly obliquely uniseriate ; spores dark brown, narrow oval, ends obtuse, with a large central gutta, 9-12 × 3-4 μ. On dead branches of *Cinnamomum Camphora*, Hakgala, September, 1908; No. 2818.

Rosellinia immersa Petch, n. sp. Perithecia superficial, embedded in a dense purple black subiculum, carbonaceous, black, broadly globose, about 1 mm. diameter, minutely rugose or almost smooth, sometimes with a slightly depressed area, 0.2 mm. diameter round the ostiolum ; ostiolum short, conical ; asci cylindric, sporiferous part 180-200 × 12-14 μ, spores uniseriate ; paraphyses linear ; spores cymbiform, slightly curved, ends obtuse, black-brown, with a hyaline coat up to 2 μ thick, 20-36 × 7-10 μ. On dead branches, Peradeniya, January, 1912; No 3344.

Diatrype conferta Petch, n. sp. Stromata small, up to 1.25 mm. diameter, 0.8 mm. high, erumpent, gregarious, circular or oval, pulvinate, black, rugose, not carbonaceous, ostiola not projecting ; internally white, then purple brown ; perithecia few in each stroma and occupying nearly the whole, irregularly globose, up to 0.5 mm. diameter, with a cylindrical, totally immersed neck, up to 0.25 mm. high, 0.12 mm. diameter ; asci, total length 70-80 μ, broadly clavate above, 12 μ diameter, with a long thin pedicel up to 35 μ long, eight-spored ; paraphyses numerous, filiform, longer than the asci, spores cylindric, curved, ends obtuse, olivaceous, bi-guttulate, 8-13 × 1.5-2.5 μ. On branches of *Camellia theifera*, Kandapola, September, 1909 ; No. 2987.

Penzigia microspora Petch, n. sp. Stromata superficial, 1-3 mm. diameter, flattened turbinate, centrally attached, up to 1 mm. thick in the centre, oval or subcircular, usually gregarious and angled by mutual interference forming tessellated sheets, sometimes confluent, purple grey with black projecting ostiola, perithecial elevations not evident, margin rounded, not brittle, internally white, fleshy, with a thin black cortex ; perithecia usually in a single layer, crowded, black, ovoid or subglobose, 0.22-0.28 × 0.18-0.2 mm. ; wall of perithecium dark reddish brown by transmitted light ; asci narrow clavate, eight-spored, spores obliquely uniseriate, sporiferous part 30-36 × 5-6 μ, with a tapering pedicel up to 30 μ long ; paraphyses linear ; spores oblong or oblong-oval, ends rounded, pale fuscous with a thick hyaline coat and a central pale band, 4-6 × 2.5-3 μ. On dead wood, Anuradhapura, December, 1919 ; No. 6213.

DISCOMYCETAE

Dothiora Symploci Petch, n. sp. Spots red-brown with a blackish margin ; apothecia amphigenous, up to 1 mm. diameter, at first black, rugose, surrounded by the upturned epidermis, the black cover splitting off, leaving the apothecium white and subgelatinous : no black stroma beneath or round the fructification ; asci broadly oval, very shortly pedicellate, thick-walled, 90-100 × 40 μ, eight-spored, spores irregularly arranegd ; paraphyses stout, about 2.5 μ diameter, branched, longer than the asci : ascospores fusoid, muriform, transverse septa about 4 μ apart, not constricted at the septa, 32-36 × 12-13 μ. On leaves of *Symplocos spicata*, Hakgala, May, 1910 ; No. 3142.

Haematomyces carneus Petch, Ann. Bot., XXXIII (1919), p. 418

This name is antedated by *Haematomyces carneus* Rehm. The species may be known as *Haematomyces cerebriformis.*

Henriquesia Ochlandrae Petch, n. sp. Perithecia erumpent, scattered, circular or elongated, up to 0.6 mm. long, 0.3 mm. broad, 0.2 mm. high, black, rough, thick-walled, opening by a longitudinal slit ; asci cylindrico-clavate, 130 × 10 μ, spores uniseriate ; paraphyses numerous, linear, not forming an epithecium ; spores oval, hyaline, 16-20 × 7-10 μ. On living leaves of *Ochlandra stridula*, Gikiyanakande, June 7, 1916 ; No. 4802.

HYPHOMYCETAE

Gliocladium microsporum Petch, n. sp. White, forming sub-cylindric or spreading lax fascicles, up to 0.6 mm. high, 0.1 mm. diameter at

the base ; conidiophores branched near the base, simple above, 4 μ diameter below, slightly attenuated upwards, 3 μ diameter above, hyaline, septate, straight, somewhat rigid, closely and minutely verrucose, bearing at the apex a few, usually four, cylindric prophialides, curved below, 8 μ long, 2 μ diameter, each bearing two to four elongated flask-shaped phialides, 8-16 μ long, 1.5 μ diameter below, the prophialides and phialides forming a lanceolate head, 16-24 × 8-10 μ ; conidia adhering in a globose mass up to 30 μ diameter ; conidia hyaline, oblong-oval, 1.5-3 × 0.75-1 μ, or subglobose, 1 μ diameter. On *Polystictus flabelliformis*, Hakgala, January, 1914 ; No. 6820.

Apparently differs from *Gliocladium penicillioides* Corda in its smaller spores, and conidiophores not thickened above.

Hormiscium pulvinatum Petch, n. sp. Tufts superficial, pulvinate or subglobose, up to 0.6 mm. diameter, 0.5 mm. high, black, pulverulent, composed of loose branching chains of conidia ; conidia not separating, blackish brown, thick-walled, smooth, broadly oval, 5-6 × 3.5-4 μ, or cuboid or subglobose, 3.5-4 μ diameter. On wood, Hakgala, September, 1914 ; No. 4240.

Helminthosporium Oryzae B. de H. On glumes of rice, Anuradhapura, February, 1920 ; No. 6173.

Helicosporium recurvum Petch, n. sp. Tufts black, effused, more or less circular : conidiophores clustered, up to 180 μ high, 6 μ diameter, brown, septate, equal ; conidia 7-8 septate, not constricted at the septa, once coiled, coil 15-19 μ diameter, with a recurved conical basal part. 6-8 μ long, 4 μ diameter. On dead mango branches, Peradeniya, November, 1914 ; No. 4334.

Some New Ceylon Plants

BY

P. J. Livera, B.Sc. (Lond.)

WITH TWO PLATES

Among the generic characters of *Alyxia* Banks, Brown (4) gave, "I. corolla fauce nuda ; II. semen semi-bipartitum ; III. albumen ruminatum corneum ; IV. embryo erectus," and added "Obs. II. Habitu et floris fructura Apocinis et veris similis, diversa albumine ruminato facillimeque in lobis separando centro tantummodo solido embryonifero, embryo rectus v. curvatus," and further "An cum *Rauvolfia* et *Ophioxylo* in propria sectione jungenda ? licet in his ovarium semi-bilobum, loculis monospermis, albumen tenue carnosum non ruminatum et embryo major foliaceus." These comments go to shew the importance of the ruminate endosperm and the two-lobed embryo as generic characters of *Alyxia* Banks.

Wight (7) described and figured a plant, *Alyxia ceylanica,* which Schumann (11), p. 151, who restored the genus *Gynopogon* Forst., making *Alyxia* Banks a synonym, renamed *Gynopogon zeylanicus.* Hooker (10) referred to the plant as *Alyxia ceylanica* Wight and noted "Very dissimilar from the other species, if indeed congeneric." Trimen (12), p. 127, called it *Alyxia zeylanica* Wight and said in a footnote "This must be referred to *Alyxia* with some doubt ; the endosperm is not ruminate."

An examination of fresh specimens of the plant shewed I. the throat of the corolla tube hairy ; II. the seeds not bipartite in the least ; III. the embryo not ruminate and not horny, but fleshy; IV. the embryo inverted. This plant, which has I. stamens free from the stylar head ; II. thecae full of pollen and without spines; III. seeds without hairs, belongs to the Plumieroideae. As its two carpels are free it comes under the section Plumiereae. Characterised by the small number of ovules in each loculus and the thin seed coat it comes under subsection Rauwolfiinae.

According to Schumann's key (11), p. 150, to the "Plumieroideae-Plumiereae-Rauwolfiinae," this plant works down to :—

A. Blumenkronenzipfel links deckend.
a. Discus O.
Sa. hangend.
I. Nahrgewebe gleichformig.....*Hunteria.*

On the other hand, Roxburgh (6) gave among the generic characters of *Hunteria* I. germ lobes *two*-seeded; II. *berries two, one or two-seeded.* Also Bentham and Hooker (9) enumerated among the generic characters of *Hunteria* Roxb.; III. antherae oblongo-lanceolatae; IV. semina ovata v. oblonga; V. folia coriacea tenuissime pennivenia; VI. cymae densae v. subpaniculatae. *Alyxia ceylanica* Wight has I. germ lobes 4-6-seeded; II. fruit a string of drupes; III. anthers obcordate; IV. seeds falcate; V. leaves thin; VI. cymes 1-3 flowered. In view of these points of difference, I consider this plant to belong to a perfectly distinct genus, which I propose to call *Petchia* after Mr. T. Petch, late of the Ceylon Department of Agriculture.

Petchia Livera gen. nov. (Apocynaceae-Plumerieae) affinis *Alyxiae* Banks, sed albumino non ruminato differt.

Frutices glabri. Folia 3-natim v. opposita, tenuis venis parum prominulis. Flores parvuli, 3-4-natim in axillis foliorum terminalium pseudo-terminales. Calyx 5-partitus, eglandulosus, segmentis brevibus. Corolla hypocrateriformis, tubo cylindraceo ad stamina dilatato, fauce esquamata; lobi 5 contorti, sinistrorsum obtegentes. Stamina prope faucem inclusa; antherae obcordatae, loculis basi inappendiculatis. Discus O. Ovarii carpella 2, distincta. Stylus filiformis; stigma capitatum, apiculo breviter 2-fido; ovula in quoque carpello 4-6, 2-seriata. Drupae 2 moniliformae, articulis falcatis 1-spermis. Semina falcata, placentam intrusam amplectentia; albumen carnosum.

Species unica, Zeylaniae.

Petchia ceylanica Livera, comb. nov., *Alyxia ceylanica* Wight, Ic. IV. pt. 2. 2 (1850) t. 1293.; Thw., Enum. Pl. Zeyl. 191 (1864); C. P. 1835; Fl. B. Ind., III. 636. (1882); Bedd., Fl. Sylv. Anal. t. 20, f. 5; Trimen F. Ceyl. III. (1895), p. 127. Wal-kaduru, S.

Hunteria Legocii Livera sp. nov. *H. Roxburghiana* Thw., Enum. Pl. Zeyl., 192 (1864) (non Wight Ic.); *H. corymbosa* Trimen, Fl. Ceyl. III. (1895) 128 ex parte; C. P. 2518. Mediya, S.

Frutex erectus, ramis teretibus, glabris, foliis breviter petiolatis lineari-lanceolatis supra nitidis utrinque glabris subcoriaceis, floribus umbellam terminalem referentibus, breviter pedicellatis, pedicellis bracteisque laccatis ; sepalis brevibus triangularibus acutis, glabris ; corolla hypocraterimorpha, tubo duplo lobos superante, staminibus infra faucem insertis, ovario glabro, carpidiis biovulatiis, stilo apice clavato.

Trimen (12), p. 128, noted under *Hunteria corymbosa* Roxb. "The shape of the leaves varies. C. P. 2518 (*H. Roxburghiana*) is a narrow-leaved form, and C. P. 1827 (*H. zeylanica*) a very broad-leaved variety." A re-examination of the two forms shewed that there were in reality two distinct species. C. P. 1827 is the true *H. corymbosa* Roxb. and differs from C. P. 2518 in the characters tabulated below :—

C. P. 1827—*H. corymbosa* Roxb.	C. P. 2518.
1. Leaves oblong-oval or lanceolate, distinctly acuminate, obtuse at the apex.	Leaves linear-lanceolate, acute, but not acuminate at the apex.
2. Calyx lobes ovate.	Calyx lobes triangular.
3. Corolla lobes falcate.	Corolla lobes circular.
4. Anthers dorsifixed, ovate with the lobes rounded at the base.	Anthers versatile, linear-lanceolate, with lobes acute at the base.

C. P. 2518 is, therefore, distinct from *Hunteria corymbosa* Roxb.

Thwaites (8), p. 192, enumerated C. P. 2518 under "? *H. Roxburghiana* Wt. Ic. t. 1294 " and remarked " This would seem to have the leaves narrower and less numerously and strongly veined than Dr. Wight's plant, as represented in his figure, but in other respects there appear, to be great similarity." Wight (7), Vol. IV., pt. 11, p. 2, in his "Explas nation of plates " noted under " t 1294 " " The venation in the figures though correct as to outline, is too conspicuous ; in the specimen it is much less distinctly seen." When we discount this excessive venation, Wight's figure t 1294 and description answer in other respects to Roxburgh's definition (6) of *Hunteria corymbosa*. It is, in fact, admitted by all that *H. Roxburghiana* Wight Ic. t. 1294 is the same as *H. corymbosa* Roxb. The other points of difference between *H. Roxburghiana* Wight and C. P. 2518 are the same as those tabulated above, and Thwaites had overlooked these differences, although he had himself drawn the floral parts in the painting of the plant C. P. 2518, preserved in the Peradeniya herbarium, and from which Plate II. is made. The re-examination of the flowers shewed that the dissections done by Thwaites, were perfectly correct.

The plant C. P. 2518 is, therefore, distinct from *Hunteria corymbosa* Roxb., and I have named it after the Rev. M. J. LeGoc, the first lecturer

in Botany at the Ceylon University College, whose teaching has done so much to stimulate the study of Botany in Ceylon.

Hunteria Legocii Liv. is a glabrous shrub with linear-lanceolate leaves 6.5-8.5 cm. long, and 1.3-2 cm. broad, acute at the apex, veins rather distant. Inflorescence a terminal umbel. Bracts ovate, minute. Calyx 0.1 cm. long. Corolla tube 0.4 cm. long, dilated at the base and towards the mouth ; lobes 0.2 cm. long, rounded. Anthers 0.1 cm. long, linear-lanceolate. Fruit with an obtuse beak.

Badulla and Rikiligasgoda. Fl. July.

Hunteria Zeylanica Gardn. ex Thw., Enum. Pl. Zeyl., p. 191 (1864).

Roxburgh (6) named a plant *Hunteria corymbosa*, " a native of Prince of Wales's Island, where it blossoms in July; in Bengal, in May." He made no mention of it in his earlier work (5). Hermann (1) mentioned a plant " Mendija," which Linnaeus (2) included under " No. 404 Apocyno-nerium " and added a description. This " No. 404 " of Linnaeus, Trimen (12) says is the same as *Hunteria corymbosa* Roxb. Retzius (3) mentions " No. 72 *Cameraria zeylanica* " and refers to " Apocynonerium Linn. Fl. Zeyl. 404 " for the description of the plant. Retzius's name is valid and is the earliest specific name for this plant and therefore the present name should be *Hunteria zeylanica* (Retz.) Gardn.

Bulbophyllum maskeliyense Livera sp. nov.

Rhizoma elongatum, repens, ramosum, teres. Pseudobulbi concurrentes, disciformes, leviter longitudinaliter sulcati, virides, monophylli. Folium sessile, oblongum, apice retusum, supra sulcatum, subtus carinatum, marginibus recurvum. Scapus ad basin pseudobulborum erectus, 2-4 florus pedunculo pallide viridi, vaginis sese partim amplectentibus. Bracteae pedicello adpressae, ovatae, acutae, membranaceae, flavescentes. Flores foveoli, sepalis divergentibus. Sepalum dorsale lineari-lanceolatum, apice acutum, glabrum 4-nervia. Sepala lateralia falcata, 4-5 nervia, acuta. Petala parva, ovata, obtusa, 3-nervia gynostemio adpressa. Labellum parvum, carnosum, mobile valde recurvum, lingulatum, obtusum, bicarinatum ad margines. Gynostemium truncatum, apice tridentatum, falcatule decurvis. Pollinia 4, ovalia. Stigma profunde excavatum, obtriangulum. Pes gynostemii longus, linearis. Ovarium obconicum 6-sulcatum.

Roots fibrous, long. Pseudobulbs naked, 0.4-0.6 cm. in diameter. Leaves on the apex of the pseudobulb, apex retuse unequal, margins entire, surface shining above and dull below. Leaves tough, leathery

1.2-2 cm. long, 0.4-0.7 cm. broad. Scape 1.8-2.5 cm. long. Bracts minute. Flowers about 0.2 cm. long. Dorsal sepal 0.5 cm. long, 0.15 cm. broad. Lateral sepals 0.5 cm. long, 0.2 cm. at the broadest part. Petals 0.25 cm. long, margins crisped. Column winged. Lip fleshy, folded back on the column, which is much shorter than the lip.

Maskeliya, August, S.B. Stedman !

Curcuma domestica var. **purpurea** Livera var. nov.

In July, 1919, at the request of Dr. Valeton of Java, a collection of *Curcuma spp.*, grown in Ceylon as Turmeric, was made by Mr. T. Petch. Among them was a plant with an immature inflorescence, its coma bracts differing from those of the ordinary *C. domestica* val., in having their upper parts a deep purple instead of white. Though the rhizome was planted out the inflorescence did not develop further. Last year, however, the plant flowered again and a closer examination of it revealed the several other points, tabulated below, in which it differed from *C. domestica* Val. The characters noted under *C. domestica* are from Valeton's (13) description of that species :—

	C. domestica Val.	*C. domestica* var. *purpurea*.
1.	Leaves oblong-lanceolate, 3.5 times longer than broad.	Leaves elliptic-lanceolate, 2.3 times longer than broad.
2.	Bracts with acute tips, white or green, 5-6 cm. long, 2.4-2.7 cm. broad.	Bracts with obtuse tips, purple spotted, 4-5 cm. long, 3 cm. broad.
3.	Coma bracts conspicuously mucronate, wholly white only with few very fine scattered brown spots near the tip.	Coma bracts not mucronate, upper half of a deep purple.
4.	Flowers protruding beyond the edge of the bracts.	Flowers included within the bract.
5.	Staminode falcate.	Staminode not falcate.

C. domestica var *purpurea* is also characterised by its smaller flowers

REFERENCES

1. Hermann, P. Musaeum Zeylanicum (1726), p. 5., Fol. 26.
2. Linnaeus, C. Flora Zeylanica (1747), p. 191, No. 404.
3. Retzius, A. J. Observationes Botanicae IV. (1786), p. 24.
4. Brown, R. Prodromus Florae Novae-Hollandiae (1810), p 469.
5. Roxburgh, W. Hortus Bengalensis (1814).
6. Roxburgh, W. Flora Indica II. (1824), p. 531.

7. Wight, R. Icones Plantarum Indiae Orientalis IV., pt. 2 (1850), p. 2. t. 1294.
8. Thwaites, G.H.K. Enumeratio Plantarum Zeylaniae (1864).
9. Bentham and Hooker. Genera Plantarum II. (1876), p. 698.
10. Hooker, J.D. Flora of British India III. (1882), p. 637.
11. Schumann, K. in Engler and Prantl's Die naturlichen Pflanzenfamilien. IV. 2 (1895).
12. Trimen, H. Handbook of the Flora of Ceylon III. (1895).
13. Valeton, Th. in Bulletin du Jardin Botanique de Buitenzorg 2nd Series No. 27 (1918), pp. 31-34.

EXPLANATION OF PLATES

PLATE I

Petchia Ceylanica Liv.

1. Branch of the plant.
2. Flower.
3. Calyx opened out.
4. Corolla tube opened out.
5, 6, and 7. Front, side, and back view of anther.
8. Gynaecium.

PLATE II

Hunteria Legocii Liv.

1. Branch of the plant.
2. Flower.
3. Upper view of corolla.
4. Corolla tube opened out.
5, 6, and 7. Front, side, and back view of anther.
8. Gynaecium.
9. and 10. Longitudinal and transverse sections of the ovary.
11. Fruit.
12. and 13. Longitudinal and transverse sections of fruit.

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Aeginetiaceae
A New Natural Family of Flowering Plants

BY

E. J. Livera, B. Sc. (Lond.)

Assistant in Systematic Botany, Department of Agriculture, Ceylon

Having for some time past been occupied with the study of that group of plants, included under the *Orobanchaceae* by Trimen (23), and their Indian allies, I felt that they occupy an anomalous position among the *Orobanchaceae* proper. I therefore extended my study to all the known species of *Aeginetia, Christisonia, Campbellia,* and *Hyobanche* and found that these genera form by themselves a natural group possessing characters which separate them sharply from the *Scrophulariaceae* on the one hand and the *Orobanchaceae* on the other. With the exception of *Aeginetia* the other genera here mentioned have been placed in more than one family by several botanists. As an enquiry into their history was of assistance to me in grouping them together under the new family proposed I give it in brief.

Aeginetia was founded by Linnaeus (1) who later (3) reduced it to a synonym of *Orobanche* ; Roxburgh (4) however restored it. Gardner (15) established the genus *Christisonia* as one of the tribe *Cyrtandreae* (*Gesneraceae*) and Wight transferred it to the *Orobanchaceae.* Wight (17) also established a new genus *Campbellia* which he considered distinct from *Christisonia* on account of its bracteolate flowers and one-celled anthers. Of the two species *Campbellia cytinoides* Wt. and *C. aurantiaca* Wt., the former has an ovary which is bi-locular in the lower part and uni-locular in the upper, while the latter has a bi-locular ovary with a perforation in the upper central part of the septum. Hooker (21) p. 321 examined the former species and reduced the genus to *Christisonia* ; Bentham (20) p. 967 examined the latter, retained the genus, and transferred it to the *Scrophulariaceae.* Bentham (20) p. 968 also transferred Thunberg's genus *Hyobanche* to the *Scrophulariaceae,* but Endlicher (10), Presl (15), Wight (17), Walpers (18), and Hooker (11) regarded it as a genus or *Orobanchaceae.*

It is very probable that the genus *Harveya* Hooker (9) belongs to this new family. Hooker (9) says: "It has the habit of the *Orobanchaceae* and it may be included among the imperfectly described species of *Orobanche* of Thunberg: but the structure of the ovary forbids its being united with that family." The limits of the family now proposed admits of the inclusion of this genus, which has one anther cell empty and subulate-acuminate. The capsule is, however, loculicidal.

The main points of difference between the *Orobanchaceae*, the *Scrophulariaceae*, and the *Aeginetiaceae* are shewn below:

Aeginetiaceae.	*Orobanchaceae.*	*Scrophulariaceae.*
Parasites with leaves reduced to scales.		Non-parasitic. (I)
Anther, one cell fertile.	Both cells fertile.	Both cells fertile. (II)
Spur, an outgrowth of the connective or a barren anther cell.	Absent, but base of anther mucronate.	Usually absent; when present an outgrowth from the anther cell and not as in the Aeginetiaceae. (III)
Ovary, one-celled or imperfectly two-celled.	One-celled.	Perfectly two-celled.
Placentae 2	4	2 (IV)
Fruit, dehisces septifragally.	Septifragally.	Septicidally or loculicidally. (V)

(I) The monotypic genus *Tozzia* L. is parasitic; *Rhinanthus* L. is also a more or less parasitic genus. Some species of *Alectra* Thunb. and of *Striga* Lour. are parasites with their leaves reduced to scales. *Cycnium tubulatum* Benth. has scales instead of leaves. The leaves of *Russelia* Jacq. are often scaly. The species of *Monttea* Gay have their leaves at times reduced to scales. (II) *Buttonia* Mc.Ken., *Sopubia* Ham., and *Graderia* Benth., have one anther cell barren but not reduced to a spur. (III) The species of *Centranthera* R. Br. have their anthers transversely spurred a ttheir bases. The loculus of the posterior anthers of some species of *Euphrasia* L. have long spurs. (IV) *Limosella* L. has its ovary shortly 2-locular at the base and 1-locular above owing to the disappearance of the septum above. *Glossostigma* Am. has either a 2-locular or a sub-1-locular ovary owing to the disappearance of the septum at the margins. (V) *Anarrhinum* Desf. and *Galvesia* Juss. have irregular dehiscence starting from a pore. *Schweinfurthia* Braun has a fragile pericarp.

The *Aeginetiaceae* like the *Orobanchaceae* are all parasitic plants whose vegetative parts are of a modified type of plant-structure, consisting principally of a branching, subterranean, rhizome-like structure which perennates from year to year on the roots of *Gramineae* or *Strobilanthes* which they intertwine and penetrate. These roots form a complete network by the fusion of adjacent parts. The point of attachment of the parasite to the host where the haustoria arise are usually swollen to a slight extent. In some species root tubers are formed at these points and from them root branches and stems grow out in various directions. These tubers, therefore, seem to serve as storehouses for the nutrition of the plant. The haustoria arise exogenously and the lateral

roots and stems endogenously from the parent root. The aerial parts grow very rapidly and in some cases are shed and the fruits and stems decay within a fortnight. The stems are usually very short and slender and rather brittle, varying from a white or cream to a purple or dark-red colour. They all turn black on drying. The leaves are represented by scales of varying sizes which are usually crowded towards the bases and more distant towards the apices of the stems. The inflorescences are racemose of various types, the corymbose and capitulum forms being the commonest. The flowers are ebracteolate or bibracteolate. The calyx is usually tubular, that of *Aeginetia* ranging from spathaceous to tubular-spathaceous. The corolla is gamopetalous and irregular. The structure of the anther is the chief distinguishing feature of this family. Of the two anther cells one only is fertile, the other either wanting as in *Campbellia* or in the form of a spur as in *Cliffordia*. The spur is also an outgrowth from the connective in *Aeginetia* and *Christisonia*. The ovary is one-celled in *Aeginetia*, *Christisonia*, and *Cliffordia*. It is partly 2-celled in *Campbellia* and completely 2-celled with a perforation in the upper portion of the septum in *Legocia*. In *Hyobanche* it is 2-celled, may-be by the fusion of the two parietal placentae. All have fruits with thin pericarps which turn mucilaginous and the seeds are then distributed by water. The seeds are albuminous with a reticulated hyaline testa. All these parasites are found in damp dark situations. Those found in situations with more light tend to develop a purple colour and those in darker places are yellowish or white. There are thus associated with the habitat of these parasites their colour, the mode of dehiscence of their fruit, and the distribution of their seeds.

This family ranges from Japan, the Philippine Islands, China with Cochin China, Java, Siam, the Malay Peninsula, and Burma to India and Ceylon where most of the species are found. The genus *Hyobanche* is restricted to South Africa. The original home of the family seems to have been in India.

This family is connected with the *Scrophulariaceae* through the genera of the tribe *Gerardieae* especially *Harveya* Hook., *Alectra* Thunb., *Buchnera* L., *Striga* Lour., and *Cycnium* E. Mey. also shew relationships with this family. The *Orobanchaceae* are related to this family through *Boschniakia* C. A. Mey. and *Lathraea* L.

THE GENERA AEGINETIA AND CHRISTISONIA

The genus *Aeginetia* was founded by Linnaeus (1) to receive one species, *Aeginetia indica*, which was published in his Species Plantarum (2). He, however, reduced it to a species of *Orobanche* (3), describing it as "*Orobanche* (*Aeginetia*) *caule unifloro, flore spathaceo.*" This genus

was restored by Roxburgh (4). The generic characters as given by Willdenow (5) are "*Aeginetia* Cal. 1-phyllus spathaceus. Cor. campanulata bilabiata. Capsula multilocularis." This last character is not true of *Aeginetia indica* L., which has a unilocular capsule.

Wallich (7) added the second, *Aeginetia pedunculata*, and third species (8) *Aeginetia abbreviata* Ham. to the genus. Walpers (12) added the fourth, *Aeginetia acaulis*, and at the time Reuter (14) monographed the genus four species were known. Miquel (19) referred *Centronia mirabilis* Bl. (6) to the genus as *Aeginatia Centronia*, thus making a fifth species of the genus.

These five species agree in the following respects :—

They are leafless herbs, the leaves being reduced to scales. Stem very short or none. *Aeginetia pedunculata* alone has a long stem. Flowers large, stalked. Bract one scale to a peduncle. Bracteoles none. Calyx spathaceous anteriorly split to the base, posteriorly acute, entire or minutely toothed ; irregularly bifid in *A. acaulis*. Corolla tubular-campanulate to infundibuliform, wide, curved or not. Limb bilobed or not, lobes 5 spreading, 2 posterior connate. Stamens included didynamous ; anthers united dehiscing along their lengths and spurred, the spur being an outgrowth from the connective. Ovary 1-locular with 2 parietal irregularly lobed placentae, not united at the centre. Style bent at the apex. Stigma peltate, dilated and lobed. Capsule sub-2-valved. Seeds minute.

It will be seen that the Linnean limits of this genus have been widened to receive the other species which were added later.

Gardner (15) established a new genus *Christisonia* to receive seven species and p. 154 says : " Besides the three species which I have been able to describe from recent specimens I believe I can give sufficiently good diagnostic characters of two other Ceylon ones from the figures above referred to ; and in my herbarium I find excellent specimens of a sixth species from the Neilgherry Mountains in the Peninsula of India, which I owe to the kindness of Dr. Wight. To these I add *Phelipaea subacaulis* of Bentham (Scrop. Ind. p. 55.), which, judging from the description, is evidently a congener." *Phelipaea subacaulis* Benth. has all the characters, enumerated above, common to the five species of *Christisonia*, but its calyx differs in not being quite spathaceous, but two-lipped and tubular-spathaceous. This is only a difference in degree. Trimen, (18) in a note on this plant, says : "The species is, perhaps, equally well placed (as by Thwaites) in *Aeginetia* and is certainly allied to *A. pedunculata*, thus connecting the two genera. A closer examination of this plant and a comparison, tabulated below, with the other six species of *Aeginetia* revealed that this plant really belongs to this genus (*Aeginetia*) to which I have therefore transferred it.

Table I.

Ebracteolate.	*Corolla.*		*Anthers.*	*Dehiscence of Anthers.*	*Spur.*	*Stigma.*
	Upper.	*Lower.*				
Aeginetia indica L.	not 2-lipped.		United.	Longitudinal.	Outgrowth of connective.	Lobed.
Aeginetia pedunculata Wall.	2 larger.	3 smaller.	United.	Longitudinal.	Outgrowth of connective.	Lobed.
Aeginetia Trimenii Liv.	2 smaller.	3 larger.	United.	Longitudinal.	Outgrowth of connective.	Lobed.
Aeginetia acaulis Walp.	2 smaller.	3 larger.	Not known. (I)	Longitudinal.	Outgrowth of connective.	Lobed.
Aeginetia Centronia Miql.	2	3	United.	Not known (II).	Outgrowth of connective.	Lobed.
Aeginetia abbreviata Ham.	2	3	Not known. (III)	Not known. (III)	Not known. (III)	Not known. (III)
Christisonia subacaulis Gardn.	2 smaller.	3 larger.	United.	Longitudinal.	Outgrowth of connective.	Lobed.

(I), (II) and (III) are unknown, but it is very probable that they are in agreement with the characters of the other species for Miquel (19) pp. 712 and 713 included them under *Aeginetia*, giving among the generic characters—" Antherae coalitae, staminum inferiorum postice in calcar conicum productis."

The two genera *Aeginetia* and *Christisonia* are not, however, connected by this species, for as shown in Table 2 the species of *Christisonia* are further distinguished by having (1) a truly tubular calyx; (11) anthers which do not dehisce longitudinally but open by a pore.

It will be seen in table I that I have made a new species *Aeginetia Trimenii*. This plant was described by Trimen (23) as *Aeginetia pedunculata*. The numerous points of difference between the two species are shewn below :—

	Aeginetia Trimenii.	*A. pedunculata.*
1.	Roots fibrous.	Roots tuberous.
2.	Stem 1-2 in., widened upwards and branched.	Stem 2-3 in., subcylindric, simple.
3.	Scales entire.	Scales emarcescent.
4.	Pedicels 1-15 in. long.	Pedicels 1-4 in. long.
5.	Bracts 0.5-1 in. long.	Bracts 0.25-0.5 in. long.
6.	Calyx swollen at the base.	Calyx narrowed at the base.
7.	Corolla not contracted at the base.	Corolla contracted at the base.
8.	Corolla lobes rounded.	Corolla lobes reniform.
9.	Upper lobes of corolla smaller	Corolla lobes almost equal.

	Aeginetia Trimenii.	*A. pedunculata.*
10.	Filaments slightly pubescent.	Filaments glabrous.
11.	Spurs flattened.	Spurs subconic.

These two species also differ in colour.

I have also restored to specific rank *Aeginetia acaulis* Walp. and *Aegineta abbreviata* Ham. which have hitherto been regarded as synonyms of *A. pedunculata* Wall. but from which and from each other they differ abundantly. I have made the new combination *Aeginetia mirabilis* (Bl.) in compliance with Art. 48 of the International rules (24).

Gardner's species of *Christisonia* fall into two groups, viz. those with two bractlets and those without bractlets. Tables II and III. shew that the ebracteolate species are also characterised by having (I) the two upper corolla lobes differing in size from the three lower ones; (II) the anthers united; (III) the spur an outgrowth from the connective ; (V) lobed stigmas, while the bibracteolate species have (I) the four upper lobes differing in size from the solitary lower lobe ; (II) the anthers free ; (III) the spur a barren anther cell ; (IV) stigmas not lobed but clavate.

Table II.

Ebracteolate.	*Corolla.*		*Anthers.*	*Dehiscence of Anthers.*	*Spur.*	*Stigma.*
	Upper.	*Lower.*				
Christisonia tubulosa Benth.	2 smaller.	3 larger.	United.	Pore.	Probably outgrowth of connective (I).	Lobed.
Christisonia Hookeri Clarke.	Not known (II).		Not known (II).	Not known (II).	Outgrowth of connective.	Lobed.
Christisonia Lawii Wight.	Not known (III).		Free in Wight's fig.	Pore.	Anth. cell in Wight's fig.	Lobed.
Christisonia calcarata Wight.	2 larger.	3 smaller.	Free in Wight's fig. (IV)	Pore.	Outgrowth of connective.	Lobed.
Christisonia tricolor Gardn.	2 smaller.	3 larger.	United.	Pore.	Outgrowth of connective.	Lobed.
Christisonia grandiflora Gardn.	2 larger.	3 smaller.	United.	Pore.	Outgrowth of connective.	Lobed.
Christisonia Thwaitesii Trim.	2 larger.	3 smaller.	United.	Pore.	Outgrowth of connective.	Lobed.

(I) Wight (17) describes the anthers of *Oligopholis tubulosa* (*Christisonia tubulosa* Benth.) as "anthers 2-celled, 1 fertile ; the other sterile subulate." This subulate process looks very much like the outgrowth of the connective.

The full description of (II), (III) and (IV) are wanting, but the fact that they are ebracteolate and that the majority of the characters known about them agree with those of the other species in this table, justifies their inclusion here.

Table III.

Bi-bracteolate.	*Corolla.* *Upper.*	*Lower.*	*Anthers.*	*Dehiscence of Anthers.*	*Spur.*	*Stigma.*
Christisonia bicolor Gardn.	4 larger.	1 smaller.	Free.	Pore.	Barren anther cell.	clavate, not lobed.
Christisonia pallida Gardn.	4 larger.	1 smaller.	Free.	Pore.	Barren anther cell.	clavate, not lobed.
Christisonia spectabilis Thw.	4 larger.	1 smaller.	Upper free, lower united. (I)	Pore.	Barren anther cell.	clavate, not lobed.
Christisonia aurantiaca Wt.	4 larger.	1 smaller.	Free.	Pore.	Barren anther cell.	umbellicate, not lobed.
Christisonia unicolor Gardn.	Gardner's description from a poor drawing.					
Christisonia zeylanica Liv. (II)	4 larger.	1 smaller.	Free.	Pore.	Barren anther cell.	rounded, not lobed.

(I) Perhaps the lower anthers are free and represented too close together in the figure. (II) The bractlets are neither represented in the drawing nor are they discernible in the specimens which are too dry to shew them; the other characters, however, agree with those of the other species in this table.

The ebracteolate group includes *Christisonia grandiflora* and *Christisonia tricolor* which were the first and second species described by Gardner (15), and these were two of the three actual specimens on which he based the genus *Christisonia*. They also possess the characters described by Gardner (15) for that genus. I have, therefore, regarded them as the types of *Christisonia* and confined that name to the group in table II. I have given *Christisonia grandiflora* Gardn. specific rank in table II, only for bringing out the points of similarity in that group more forcibly; I have treated it as a variety in the enumeration of the several species.

In view of the several points of difference between the ebracteolate and bibracteolate species of *Christisonia* I have generically separated the latter group and called it *Cliffordia* after Sir Hugh Clifford —our present governor, who was the first patron of the Ceylon Natural History Society, to whom and to Lady Clifford I have the honour of dedicating it. In order to bring out more forcibly the characters of this group I have in table III regarded *Christisonia pallida* Gardn. as a species, but I have enumerated it as a variety of *Christisonia bicolor* Gardn. with which it is connected by intermediates. Petch (25) p. 696 says: "*Christisonia bicolor* var. *spectabilis*, differs from *Christisonia bicolor* in its rhizome, its narrower calyx and corolla tube, its glabrous calyx, and its lunate stigma. *Christisonia bicolor* has a more or less reniform stigma, that of var. spectabilis is laterally elongated and decurved at the ends, resembling to some extent a croquet hoop. In some of the herbarium specimens of the latter the stigma is a centimetre from side to side.

This should be separated from *Christisonia bicolor* as *Christisonia spectabilis* Thwaites. Hooker (21) reduced *Christisonia aurantiaca* Wt. (17) t. 1486 to a synonym of *Christisonia bicolor* Gardn., but the former has (I) scales glabrous ; (II) flowers corymbose ; and (III) long pedicelled; (IV) calyx teeth mucronate; (V) corolla tubular; (VI) stigma large hairy, umbellicate, while the latter has (I) scales pubescent; (II) flowers racemose, and (III) sessile or shortly pedicelled ; (IV) calyx teeth acute but not mucronate ; (V) corolla infundibuliform ; (VI) stigma reniform. I have therefore regarded *Christisonia aurantiaca* Wt. as a distinct species. I have placed *Christisonia unicolor* Gardn. in this group, but unfortunately the full description of this plant is not available. Trimen (22) p. 240 says : "as no specimens corresponding with this figure (on which Gardner based his *Christisonia unicolor*) exist, *C. unicolor* Gardn. must ever remain indeterminable. I have also separated a new species, a drawing and specimens of which are in the Peradeniya Herbarium under *Christisonia Thwaitesii* Trim. This species, however, differs from *C. Thwaitesii* Trim. as shewn below :

	C. zeylanica.	*C. Thwaitesii.*
I.	Roots wiry.	Roots coral-like.
II.	Scales ovate, acute.	Scales rounded, obtuse.
III.	Flowers all crowded together in a head on a short stem.	Flowers racemose, distant on an elongated stem.
IV.	Calyx 0.75 in. long, tubular, lobes shallowly cleft.	Calyx 1-1·5 in. long, semispathaceous, deeply 2-lipped ; upper 2 toothed, lower 2-cleft.
V.	Corolla 2-lipped, upper 4 lobes larger than the lower one.	Corolla 2-lipped, upper two lobes smaller than the three lower ones.
VI.	Corolla tube erect, campanulate.	Corolla tube curved, infundibuliform.
VII.	Corolla lobes with entire margins.	Corolla lobes with fimbriate margins.
VIII.	Anthers free, dehiscing longitudinally.	Anthers united, opening by a pore.
IX.	Spur a barren anther cell.	Spur an outgrowth from the connective.
X.	Filaments of almost equal lengths.	Filaments upper longer.
XI.	Stigma not lobed but circular.	Stigma lobed, the two lobes, together forming a reniform plate.

THE GENUS CAMPBELLIA

Wight (17) instituted the genus *Campbellia* for two South-Indian species of *Orobanchaceae*. The chief generic characters are (1) stamens didynamous anthers one-celled opening by a pore at the apex ; (2) style simple, stigma capitate ; (3) ovary spuriously two-celled at the base one-celled at the apex, placentation parietal ; (4) calyx bibracteolate. Wight's generic description (17) is based on *Campbellia cytinoides*, but from the order of publication *Campbellia aurantiaca* is the type species of the genus *Campbellia*. The comparison tabulated below shows how the two species of *Campbellia* differ.

		Campbellia cytinoides.	*C. aurantiaca.*
Corolla.	Upper.	4 large.	4 large.
	Lower.	1 small.	1 small.
Anthers.		Free, not didynamous.	Free, didynamous.
Anth.-cells.		One.	One.
Dehiscence.		Porous.	Longitudinal.
Spur.		None.	Outgrowth of connective.
Ovary.		One locular at apex. two locular at the base.	Two-locular.

I consider the four points of difference of sufficient importance to separate them generically. I have, therefore, created another new genus *Legocia* which I have great pleasure in dedicating it to Father Legoc, who needs no introduction to Ceylon Botanists.

Aeginetiaceae Liv. fam. nov. Ord. Personales.

Herbae aphyllae, albae v. purpurae, ad radices parasiticae, basi saepius incrassatae squamisque imbricatis obtectae. Caules seu scapi e basi squamifera erecti, breves v. elongati, simplices v. parum ramosi, squamis alternis dense confertis v. dissitis, superioribus floralibus bracteiformis. Flores ad axillas bractearum solitarii, sessiles v. pedunculati, pauci v. in spicam densam terminalem conferti, v. in inflorescentiam centripetam dispositi, bracteolis 2 sub calyce v. ebracteolati. Flores hermaphroditi, irregulares. Calyx inferus gamosepalus, 4-5-dentatus v. antice v. postice fissus, spathaceus loborum aestivatione aperta. Corolla gamopetala, tubo cylindraceo ventricoso v. superne ampliato, recto v. saepius incurvo ; limbus oblique patens v. plus minus 2-labiatus, lobis 5 saepius latis imbricatis posticis interioribus. Stamina 4 didynama v. aequalia. infra medium tubum corollae affixa, lobis alterna, saepius inclusa filamentis parum incrassata. Antherae sub apice tubi conniventes v. liberae, dorsifixae ; loculus alter antherarum omnium

cassus late clavatus. Discus hypogynus obscurus v. latam brevemque productus, nec in eodem genere constans. Ovarium superum, lata basi affixum, 1-loculare, carpellis 2 compositum v. imperfecte 2-loculare placentis parietalibus v. septo adnatis. Stylus terminalis, simplex, stigmate dilatato orbiculato peltato v. in lobos 2 diviso, supra papilloso, placentis 2 ovulis numerosis fere undique tectae. Ovula anatropa. Capsula saepius calyce inclusa, subglobosa, carnosa demum deliquescens. Semina numerosissima, minima, testa foveolata-reticulata. Albumen carnosum. Embryo prope hilum minutus, cotyledonibus indistinctis.

Key to the genera.

Ovary 1-locular.	
Anthers united.	
Anthers dehiscing along their length.	1. Aeginetia.
Anthers opening by a pore.	2. Christisonia.
Anthers free.	3. Cliffordia.
Ovary 2-locular below and 1-locular above.	4. Campbellia.
Ovary 2-locular with a perforation in the upper central portion of the septum.	5. Legocia.
Ovary perfectly 2-locular.	6. Hyobanche.

I. AEGINETIA

Linn. Syst. ed. I. (1755).

Centronia Blume Bijdr. 776 (1826). *Tronicena* Steud. Nom. ed. 2 11. p. 721(1841). *Centronota* DC. ex Meissn. Gen. p. 303 (213) (1840): et Prodr. ix. p. 286 (1846). *Gasparinia* Endl. Gen. p. 1408 (1840).

Aeginetia indica Linn. Sp. Pl. ed. i. p. 632. Roxb. Cor. Pl. 1. p. 63, t. 91 ; Roxb. Fl. Ind. iii. p. 30 ; Reuter in DC. Prodr. xi. p. 43 ; Wall. Cat. 3964; Benth. Scroph. Ind. p. 55; Wight. Ill. t. 158b, f. 5 ; Wight. Icones. t. 895 ; Dalz. & Gibs. Bomb. Fl. p. 202 ; Griff. Ic. Pl. Asiat. t. 423; Thw. Enum. Pl. Zeyl. p. 221 ; Hooker in Fl. B. Ind. iv. p. 320 ; Trimen Fl. Ceyl. iii. p. 261. *Orobanche Aeginetia* Linn. Sp. Pl. ed 2. p. 883. *Tsiam-cumula* Rheede Hort. Malab. XI, p. 97, t. t. 47.

Distribution. India, Ceylon, Burma, China, Japan, Philippine Islands, and Malay Peninsula.

Aeginetia pedunculata Wall. Pl. As. Rar. iii. p. 13, t. 219 ; Reuter in DC. Prodr. xi. p. 43 ; Wight. I 11. t. 158b, f. 6; Wight Ic. t. 1421 ; Hooker in Fl. B. Ind. iv. p. 320 (exclud. syn.) *Orobanche pedunculata* Roxb. Hort. Beng. p. 45 ; Roxb. Fl. Ind. iii. p. 29.

Distribution. India, Cochin China, Java.

Aeginetia Trimenii Liv. sp. nov. *Aeginetia pedunculata* Trim. (non Wall.) in Fl. Ceyl. iii. p. 261 (1895) (exclud. syn.) Herba parasitica, erecta, 5-6 poll. alta, glabra. Caules divisi, crassi, erecti, rigidi, foliis viridibus destituti, squamis brevibus alternis ovatis acutis integris carnosis praediti. Squamae distantes, pauci. Flores pauci, 3-4 ut. videtur, cymosae dispositi, usque ad 1 poll. pedicellati, bracteis brevibus carnosis ovatis acutis basi vaginantibus suffulti. Calyx spathaceus, basi ventricosus, glaber, antice ad basin fissus. Corolla tubulosa, bilabiata, labio superiore minore. Stamina 4, inclusa, didynamia, filamentis brevibus; antherae lato-oblongae ; in staminibus longioribus antherae loculi ambo perfecti, in brevioribus unus perfectus, alter rassus connectivus in calcare longo productus. Ovarium ovoideum, uniloculare stylo apice inflexo superne stigmate magno transverso bifido minute glanduloso praeditum ; placentae duae, magnae, multipartitae undique ovuliferae.

Distribution. Ceylon.

Aeginetia abbreviata Ham. in Wall. Cat. n. 3965: Benth. Scroph. Ind. p. 45 : Reut. in DC. Prodr. xi. p. 43 : Walp. in Nov. Act. N. Cur. xix. Suppl. p. 400.

Distribution. India.

Aeginetia acaulis Walp. Repert. iii. p. 481 ; Reut. in DC. xi. p. 43. *Orobanche acaulis* Roxb. Fl. Ind. iii. p. 29. Pl. Cor. t. 292.

Distribution. India.

Aeginetia mirabilis (Bl.) Liv. comb. nov. *Centronia mirabilis* Bl. Bijdr. p. 776; R. Br. in Horsf. Pl. Jav. Rar. p. 122. *Gasparinia mirabilis* Endl. ex Zoll. in Nat. en. Genesk. Archief. ii. p. 7. *G. admirabilis* Hassk. Cat. p. 155. *Centronota mirabilis* DC. Prodr. ix. p. 268. *Aeginetia Centronia* Miq. Fl. Ind. Bat. ii. p. 713.

Distribution. Java.

Aeginetia subacaulis (Benth.) Liv. comb. nov. *Phelipaea subacaulis* Benth. Scroph. Ind. p. 55; Walp. Repert. Bot. Syst. iii. p. 463 ; Reut. in DC. Prodr. xi. p. 11: *Christisonia subacaulis* Gardn. in Calc. Journ. Nat. Hist. viii. p. 162 ; Hooker in Fl. B. Ind. iv. p. 321; Trimen Fl. Ceyl. iii. p. 262; *Campbellia subacaulis* Benth. in Gen. Pl. ii. p. 967.

Distribution. India, Ceylon.

Aeginetia siamensis (Craib) Liv. comb. nov. *Christisonia siamensis* Craib in Kew Bull. 1914, p. 129.

Distribution. Siam.

Aeginetia Saulierei (Dunn) Liv. comb. nov. *Christisonia Saulierei* Dunn in Kew Bull. 1914, p. 30.

Distribution. India.

Aeginetia Wightii (Elmer) Liv. comb. nov. *Christisonia Wightii* Elmer leaflets Philip. Bot. viii. 2793.

Distribution. Phillipine Islands.

Aeginetia Rodgeri (Sm. & Banerji) Liv. comb. nov. *Christisonia Rodgeri* Smith & Banerji in Records Bot. Surv. India vi., p. 30.

Distribution. Burma.

Aeginetia Scortechinii (Prain) Liv. comb. nov. *Christisonia Scortechinii* Prain in Journ. As. Soc. Beng. lxiii. 205.

Distribution. Malay Peninsula.

II. CHRISTISONIA

Gardn. in Calc. Journ. Nat. Hist. viii, p. 153. *Oligopholis* Wt.; Ic. iv. 5. t. 1422 (1850).

Christisonia tricolor Gard. l. c. p. 156. Thw. Enum. Pl. Zeyl., p. 222- Hooker in Fl. B. Ind., p. 323; Trimen Fl. Ceyl. iii., p. 263. var. *grandiflora* Hooker in Fl. B. Ind. iv., p. 323; Trimen Fl. Ceyl. iii, p. 264, *Christisonia grandiflora* Gard. l. c. p. 155. Thw. Enum. Pl. Zeyl. p. 221.

Distribution. Ceylon.

Christisonia calcarata Wt. Ic. t. 1426; Hooker in Fl. B. Ind. iv. p. 322. *Christisonia Stocksii* Hook. Ic. Pl. t. 836; Dalz. & Gibs. Bomb. Fl. 202.

Distribution. India.

Christisonia Lawii Wt. Ic. t. 1427; Dalz. & Gibs. Bomb. Fl. p. 202; Hooker in Fl. B. Ind. iv, p. 322.

Distribution. India.

Christisonia tubulosa Benth. in Gen. Pl. ii, p. 982; Hooker in Fl. B. Ind. iv. p. 321. *Oligopholis tubulosa* Wt. Ic. t. 1422 & II l. t. 158b, f. 7.

Distribution. India.

Christisonia Hookeri Clarke ex Hooker in Fl. B. Ind. iv. p. 321.

Distribution. India.

Christisonia Thwaitesii Trimen in Journ. Bot. xxxiii. p. 40 & Fl. Ceyl. iii, p. 265.

Distribution. Ceylon.

III. CLIFFORDIA Liv. gen. nov.

Calyx tubulosus 5-dentatus, dentibus mucronatis v. latis obtusissimis aequalibus. Corollae tubus elongatus, rectus v. subincurvus, superne ampliatus: limbus bilabiatus, lobis 5 rotundatis, integris, 4 posticis altius connatis. Stamina 4 didynamia libera, inclusa v. breviter exserta: antherarum loculus alter perfectus poro dehiscens, alter cassus angustus subulato-acuminatus. Ovarium uniloculare placentis

2 magnis late 2-fidis v. sub-2-partitis, irregulariter dilatatis, undique ovuliferis : stylus apice inflexus stigmate dilatato v. clavate non lobato. Capsula perfecte 2-valvis. Semina numerosissima, minima, subglobosa, testa reticulata. Scapi breves, simplices, crassiusculi v. longiores tenuiruioresque ad apicem dense squarrosi, squamis ovatis. Flores magni, in scapo pauci, pedicellati, bibracteolatis.

Cliffordia bicolor (Gardn.) Liv. comb. nov. *Christisonia bicolor* Gardn. l. c. p. 160; Thw. Enum. Pl. Zeyl. p. 222. Hooker in Fl. B. Ind. iv. p. 322; Trimen in Fl. Ceyl. iii. p. 264. var. *pallida* (Gardn.) Liv. comb. nov. *Christisonia pallida* Gardn. l. c. p. 159. *Christisonia bicolor* var. *pallidiflora* Thw. Enum. Pl., Zeyl. p. 222 ; Trimen Fl. Ceyl. iii. p. 264.

Distribution. India, Ceylon.

Cliffordia spectabilis (Thw.) Liv. comb. nov. *Christisonia spectabilis* Thw. ex. Trimen in Journ. Bot. xxiii. p. 241. (1885). *Christisonia bicolor* var *spectabilis* Trimen in Journ. Bot. xxiii. p. 241 (1885) & Fl. Ceyl. iii. p. 264. *Christisonia albida* Trimen (non Thw.) in Fl. Ceyl. ii. p. 265.i

Distribution. Ceylon.

Cliffordia aurantiaca (Wt.) Liv. comb. nov. *Christisonia aurantiaca* Wt. Ic. t. 1486.

Distribution. India.

Cliffordia unicolor (Gardn.) Liv. comb. nov. *Christisonia unicolor* Gardn. l. c. p. 161.

Distribution. Ceylon.

Cliffordia zeylanica Liv. sp. nov.

Herba erecta, glaberrima. Caules simplices 0.3 in. crassi, squamis ovatis basin sparsis ad apicem densis obtectis. Inflorescentia densa centripeta ; pedicelli 0.5. in. erecti. Calycis glabri tubus 0.8 in., cylindricus, foveolatus ; dentes lati triangulares obtusi. Corollae tubus 1 in., cylindricus, albus ; limbi lobi 5 rotundati, paullo reflexi. Stamina brevitor exserta ; filamenta glabra. Ovarium 0.3 in. altum, ovoideum stylo exserto ; stigma peltatum rotundatum.

Distribution. Ceylon.

IV. LEGOCIA Liv. gen. nov.

Calyx tubulosus, 5-fid, lobis valvatis. Corollae tubus brevis erectus, superne ampliatus; limbus obliquus, 5-lobus, lobis patentibus rotundatis, 4 posticis majoribus. Stamina 4 didynamia, libera, tubo affixa, exserta, filamentis crassiuscule filiformibus ; antherarum loculus perfectus basi acutiusculus longitudinaliter dehiscens alter deficiens Ovarium perfecte 2-loculare septo perforato ad apicem, placentis in. utroque loculo geminis ; stylus elongatus apice inflexus, clavatus, stigmate dilatato capitato oblongo ; ovula numerosa. Capsula ovata, peri-

carpia fragilis demum deliquescens, Semina numerosissima, ovoidea, testa striata. Herba nana, crassa, carnosa, colorata, simplex, aphylla, squamis imbricatis obtecta. Spicae breves, terminales, pedicellis brevibus, 2-bracteolatis. Flores magni 2-bracteolatis.

Legocia aurantiaca (Wt.) Liv. comb. nov. *Campbellia aurantiaca* Wt. Ic. t. 1424. *Christisonia alibida* Thw. ex Hooker (ex parte) in Fl. B. Ind. iv, p. 323.

Distribution. India, Ceylon.

V. CAMPBELLIA

Wt. Ic. iv. part iii. p. 5 (1850) emended.

Calyx tubuloso-campanulatus, irregulariter 5-dentatus, dentis valvatis. Corollae tubus erectus; limbus obliquus 5-lobus, lobis patentibus rotundatis, 4-posticis majoribus. Stamina 4 non didynamia, libra, tubo affixa exserta; filamentis crassiuscule filiformibus; antherarum loculus alter perfectus poro dehiscens, alter deficiens. Ovarium basin 2-loculare apice 1-loculare placentis in utroque loculo geminis ; stylus elongatus, apice inflexus clavatus, stigmate dilatato oblongo ; ovula numerosa. Capsula ovoidea. Semina numerosissima testa laxe reticulata. Herba parasitica, nana, crassa, carnosa, colorata, simplex, aphylla, squamis obtectis. Racemi densi, breves, terminales, 2-bracteolatis. Flores magni, 2-bracteolatis.

Campbellia cytinoides Wt. l. c. p. 6, t. 1425; Trim. Fl. Ceyl. iii, p. 265. *Phelipaea cytinoides* Reuter in DC. Prodr. xi. p. 14. *Christisonia neilgherrica* Gardn. in Calc. Journ Nat. Hist. viii. p. 157; Hooker in Fl. B. Ind. iv. p. 322.

Distribution. India, Ceylon.

VI. HYOBANCHE

Linn. Mant. ii. p. 155 (1771). *Haematobanche* Presl, Epim. Bot. 249 (1850).

Hyobanche sanguinea Linn. Mant. ii. 253.

Distribution. South Africa.

Hyobanche atropurpurea Bolus in Hook. Ic. Pl. t. 1486.

Distribution. South Africa.

Hyobanche glabrata Hiern in Dyer's Fl. Cap. iv. ii. 417. *Haematobanche sanguinea* Presl, l. c.

Distribution. South Africa.

Hyobanche rubra N.E. Br. in Kew Bull. 1901. p. 129.

Distribution. South Africa.

Hyobanche robusta Schonland in Kew Bull. 1913. p. 301.

Distribution. South Africa.

REFERENCES

1. Linnaeus, C. Systema Naturae ed. 1. (1735).
2. Linnaeus, C. Species Plantarum ed. 1. p. 632 (1753).
3. Linnaeus, C. Species Plantarum ed. 11. p. 883 (1762).
4. Roxburgh, Wm. Plants of the Coast of Coromandel 1. p. 63 (1795).
5. Willdenow, C. L. Species Plantarum iii. p. 347 (1800).
6. Blume, C. L. Bijdragen Tot de Flora v. Nederlandsch Indie pp. 776-777 (1826).
7. Wallich, N. Plantae Asiaticae Rariores iii. p. 13 (1832).
8. Wallich, N. Catalogue. (1828-49).
9. Hooker, W. J. Icones Plantarum t. 118 (1837).
10. Endlicher, S. Iconographia Generum Plantarum p. 728. (1836-40).
11 Hooker, W. J. In Lond. Journ. of Botany iii. p. 142 t. 2 (1844).
12 Walpers, G. G. Repertorium Botanices Systematicae iii. p. 481 (1844-45).
13 Bentham, G. in De Candolle's Prodromus x. p. 506 (1846).
14. Reuter, in De Candolle's Prodromus xi. pp. 43,44 (1847).
15. Gardner, G. in Calcutta Journ. Nat. Hist. viii. pp. 153-162 (1847).
16. Presl, C. B. Epimeliae Botanicae (1849).
17. Wight, R. Icones Plantarum Indiae Orientalis iv. (1850).
18 Walpers, G.G. Annales Botanicae Systematicae iii. p. 206 (1853).
19. Miquel, F. A. W. Flora Indiae Bataviae ii. p. 713 (1856).
20. Bentham,G. in Bentham &Hooker's Genera Plantarum ii.(1876).
21. Hooker, J. D. in Flora British India iv. p. 320-324 (1885).
22. Trimen, H. in Journal of Botany xxiii. p. 506 (1885).
23. Trimen, H. Flora Ceylon iii. pp. 260-266 (1895).
24. International Rules of Botanical Nomenclature, p. 46 (1912).
25 Petch, T. in Annals of Botany, pp. 679-697 (1924).

Revisions of Ceylon Fungi
Part VIII

BY

T. Petch, B.A., B.Sc.

Director, Tea Research Institute, Ceylon

343.—**Mycena tenerrima** Berk.

This species was recorded for Ceylon by Berkeley and Broome in Fungi of Ceylon, No. 127, from Thwaites 861. Recent specimens have been collected on decaying inflorescences of *Parkia Roxburghii*, and on dead bark scales on the trunks of living jak trees (*Artocarpus integrifolia*).

The pileus is 2-4 mm. diameter, campanulate or conico-campanulate, white, membranous, feebly sulcate at the margin, pruinose with loose subglobose, polyhedral, or ovoid cells, 20-40 μ diameter, which are sometimes densely covered with blunt spines, sometimes with scattered acute spines, up to 8 μ high, occasionally bifid. The stalk is usually 12-15 mm. long, sometimes up to 3·5 cm. long, 0·5 mm. diameter at the base, attenuated upwards, white, translucent, tomentose at the base, clothed with spreading white hairs, which are up to 150 μ long, 10 μ diameter, flexuose, equal, hyaline, minutely spinulose, rounded at the apex. The gills are white, rather broad, free, the outer edge bearing club-shaped cystidia, with a stalk about 30 μ long and 8 μ diameter and a globose (24-30 μ) or ovoid (30×24 μ) head, everywhere spinulose. The spores are oblong-oval, white, 8-10×4-5 μ.

Lange (Studies in the agarics of Denmark, Part I) states that in *Mycena tenerrima* the loose cells on the pileus are spherical or oval, densely warted; the cystidia minutely warted, somewhat variable, the apex either obtuse, obtuse with a hair-like appendage, or gradually tapering into a hair-like appendage: the hairs on the stem acute at the apex and somewhat inflated at the base; the spores broadly ovate, 8-9·5×6-6·5 μ.

The Ceylon fungus appears to differ from *M. tenerrima* in microscopic details, especially as regards the cystidia. It also differs in not

having a basal disc. There are specimens with a basal disc in Thwaites 861 in Herb. Peradeniya, but they are another species, which has a thicker smooth stalk.

344.—Mycena clavulifer B. & Br.

This species was described from Thwaites 803 in Fungi of Ceylon, No. 126. The pileus was said to be beset with clavate stiff hairs. Recent examples have been collected on dead twigs, and on decaying inflorescences of *Parkia Roxburghii*.

The pileus is up to 5 mm. diameter, campanulate, becoming almost plane, white, with a brownish yellow spot in the centre, sulcate almost to the centre, covered with scattered, erect setae, minutely pruinose, margin fimbriate. The setae are up to 300 μ high, spear-shaped, cylindric and about 16 μ diameter below, with an oval head about 100 μ high and 36 μ broad, smooth; the wall is about 2 μ thick below, thinner above, and the contents are granular. The superficial hyphae of the pileus have free, spinulose tips, up to 10 μ long. The margin of the pileus bears cylindric or irregularly inflated hairs, up to 90 μ long, 18 μ diameter at the base, tapering to 14 μ at the apex, closely and strongly spinulose, the shorter hairs spinulose to the apex, the longer with a solid tip which is minutely warted. The stalk is hyaline, about 1 cm. high, 0·3 mm. diameter, clothed with the same setae as the pileus, and arising from a white radiating disc. The gills are white, ventricose, adnate, and the spores white, narrow-oval, 6×3 μ. In the specimens of Thwaites 803 in Herb. Peradeniya, the spores are broader, 8×5 μ; these specimens are on decaying palm tissue.

345.—Mycena paediscula B. & Br.

This species was described by Berkeley and Broome from Thwaites 828 in Fungi of Ceylon, No. 129, as "Candidus, minimus, pileo subgloboso sulcato; stipite capillari, lamellis adnatis. Pileus half a line across; stem 1 line high." Specimens have been collected recently on decaying inflorescences of *Parkia Roxburghii*.

The pileus is up to 5 mm. diameter, campanulate, obtuse or strongly umbonate, becoming plane, pale yellow, becoming white, membranous, glabrous, margin crenate, radially striate. The stalk is up to 1 cm. high, 0·3 mm. diameter, white, translucent, becoming pale brown, minutely pulverulent, sometimes with a few brown spreading fibrils at the base. The gills are pale yellow, then white, few, distant, arched, decurrent. The spores are white, narrow-oval, 5-8×3 μ.

Thwaites sent another collection and a figure of this species (No. 929), which was assigned by Berkeley and Broome to *Mycena citrinella* P.

It is a smaller and more delicate species than *M. citrinella*, less brightly coloured, with strongly decurrent gills, and the stalk not viscid. As it will revive after drying, it should probably be referred to *Marasmius*. In the part of Thwaites 828 in Herb. Peradeniya, the stalks are up to 6 mm. long.

346.—Mycena heliscus B. & Br.

Berkeley and Broome described this species in Fungi of Ceylon, No. 128, from Thwaites 934, *cum icone*, as "Pileo hemisphaerico sulcato plumbeo stipiteque capillari albo pruinosis: lamellis paucis crassis adnatis. On dead twigs. Gregarious; pileus 1 line across, hemispherical, lead-coloured, deeply sulcate, pruinose; stem 1 inch high, white, thread-shaped, pruinose like the pileus; gills few, thick, white, adnate."

It has occurred during recent years on decaying stumps under bell glasses at the laboratory, Peradeniya. The pileus is up to 6 mm. diameter, at first hemispherical or campanulate, then convex or almost plane, membranous, at first French grey, then greyish white, darker in the centre, sometimes white from the first, sulcate to the centre, smooth, margin sometimes serrate. The stalk is up to 2·5 cm. long, filiform, 0·15-0·3 mm. diameter, white, subtranslucent, pruinose with white particles below, glabrous and shining above, equal or inflated at the apex, slightly inflated at the base, sometimes with a few white strigae extending over the substratum. The gills are white, becoming yellowish, distant, rather broad, rounded behind, adnate, or arcuate and decurrent on the larger, expanded specimens, of either one or two lengths, united behind over the apex of the stalk. The spores are narrow-oval, sometimes clavate, acute at one end, 7-9×3-4 μ.

The fungus is not readily putrescent, and revives if moistened after drying. It should presumably be referred to *Marasmius*. Berkeley and Broome cited Thwaites 944 for this species, but the figure is marked 934. Thwaites 944, in Herb. Peradeniya, is *Psathyrella furfurella* B. & Br.

347.—Mycena corticola Schum.

This species was recorded for Ceylon by Berkeley and Broome in Fungi of Ceylon, No. 127*, with the note, "a white variety with pale brown flesh." It was said to be Thwaites 1217, *cum icone*; but the figure 1217 is marked by Thwaites, "specimens not dried." Consequently the record was based on the figure only.

The figure shows six examples, evidently on a bark scale from a standing tree. The pileus is hemispherical or campanulate, up to 4 mm. diameter, sulcato-striate almost to the centre, grey in the centre, be-

coming white outwards. The stalks are white, curving upwards, 5 mm. high, 0·25 mm. diameter. The gills are ventricose, but it is not possible to say from the small figure of the section whether the artist intended them to be adnate or free.

Without specimens, it is impossible to decide what this species was. Specimens which appear to match the figure have, however, been collected on tree trunks at Peradeniya. In these the pileus is cylindric or campanulate, apex obtuse, rounded, up to 5 mm. diameter and 3 mm. high, margin crenate, greyish brown in the centre, becoming white outwards, feebly sulcato-striate almost to the centre, pruinose with white, spherical, spinulose cells, up to 50 μ diameter. The stalk is about 1 cm. high, 0·5 mm. diameter, curved, white, translucent, minutely pruinose, with a white tomentose ring at the base. The gills are somewhat distant, broad, ventricose, adnate, pallid; they bear globose, shortly stalked cystidia, up to 20 μ diameter, which are covered with blunt spines up to 2 μ long. The spores are white, broadly oval, 6-8×4-6 μ. The fungus has an alkaline smell.

This species may be known as *Mycena dendrophila* Petch, n. sp. Type specimen, No. 4369, Peradeniya, December 13, 1914.

348.—Crepidotus epicrocinus B. & Br.

Fresh specimens of this species had not been found, when the Ceylon species of *Crepidotus* were re-described in Ann. Perad., IX, pp. 223-227. It was collected in March, 1925, on a fallen branch.

The pileus is sessile, attached almost laterally by white strigae, pale yellow, very minutely tomentose. The gills are pallid, becoming pale brown, ventricose, attenuated behind, moderately crowded. The spores are spherical, 4-6 μ diameter, rather coarsely warted.

The type figure shows radiating red streaks on the pileus. These were not present on the recent specimens.

349.—Psathyrella disseminata P.

In Ann. Perad., IV, p. 397, the writer pointed out that Berkeley and Broome divided Thwaites 942 into two species, one of which they assigned to *Psathyrella disseminata* P., while the other was described as a new species, *Psathyrella ctenodes* B. & Br. Paintings were furnished by Thwaites of both these forms. That assigned to *Psathyrella disseminata* shows a cylindrico-campanulate pileus, with a rounded apex, while that named *Psathyrella ctenodes* has the apex slightly umbonate. This variation occurs in the one species, and there can be little doubt that the two paintings represent the same species.

Because of certain supposed differences in microscopic details, Berkeley and Broome's name, *ctenodes*, was adopted for this species, and it was referred to *Psathyra*, as the spores are brown. The recent publication of a full description of *Psathyrella disseminata* by Buller (Researches on Fungi, vol. III) gave an opportunity of revising that determination, and as a result it appears that the Ceylon fungus should be referred to *Psathyrella disseminata*.

The pilocystidia, the spherical cells on the pileus, the cheilocystidia, and the caulocystidia are the same on the Ceylon fungus as those described and figured by Buller for *Psathyrella disseminata*. The pileus is plicato-sulcate almost to the centre, and the margin is more regularly crenate than appears in figures of *Psathyrella disseminata*. Coarse white, long-triangular strigae extend from the base of the stalk over the substratum; these are well shown in the type figure of *Psathyrella ctenodes*, and it was probably this feature which induced Berkeley and Broome to describe it as a new species.

The red strands described by Buller are well-developed in soil which has been thrown on the host stump. In Ceylon specimens they are reddish brown. It may be noted that in Ceylon this species will develop in its usual thousands on the upper side of stumps which have been dug up, and left lying with only two or three points in contact with the ground.

Buller describes the spores of *Psathyrella disseminata* as black in mass on white paper, but dark-brown when examined with the microscope, oval, 9-11×4-5 μ. In the Ceylon form, the spores are purple brown in mass, dark brown by transmitted light, 5-10×3·5-4·5 μ, oval, inequilateral.

350.—Coprinus setulosus B. & Br.

The original description of this species, in Fungi of Ceylon, No. 310, is "Pileo cylindrico campanulato obtuso usque ad discum striato setis fulvis undique obsito; stipite fistuloso candido sursum attenuato; lamellis angustissimis adnexis (No. 845, cum icone; No. 936)."

This species grows on dead wood or among dead leaves, etc. The pileus is at first cylindric, obtuse, then conico-campanulate, up to 2·5 cm. high. Frequently it is persistently cylindric. It is pale brown or reddish brown at first, then livid or greyish with a brown central disc, striate up to the disc, covered with erect, rigid, brown setae up to 0·4 mm. long. The stalk is up to 11 cm. high, 1·5-3·5 mm. diameter, white, shining, finely striate, fragile, hollow, somewhat thickened and yellowish at the base. The gills are ascending, adnexed, up to 4 mm. broad in large examples. The spores are subglobose, 8-10 μ, or ellipsoidal,

8×6 μ, and the cystidia, globose, 20-30 μ diameter. The setae on the pileus are pale yellow brown, with an elongated oval base about 12 μ diameter, attenuated upwards, straight, or slightly curved above, acute, thick-walled, usually not septate.

351.—Coprinus castaneus B. & Br.

Berkeley and Broome described this species, in Fungi of Ceylon, No. 311, as "Pileo digitaliformi pallide castaneo glabro; stipite sursum attenuato basi truncato glabro eximie fistuloso; lamellis angustis ascendentibus adnatis (No. 935, cum icone)."

This species has been found growing among dead leaves, and on decaying coconut buds, in the latter case from thick white plates and strands of mycelium between the leaf bases. In the former situation, it is up to 10 cm. high, with a pileus up to 2·5 cm. diameter; in the latter, up to 15 cm. high, with stalks up to 1 cm. diameter, and a pileus up to 7·5 cm. diameter.

The pileus is at first cylindric, obtuse, then almost plane, with a revolute margin, and plicato-sulcate almost to the centre. At first, it is densely clothed with long, white, silky or floccose scales, which disappear from the centre outwards, the pileus ultimately being smooth and brown in the centre, white (unexpanded) or hyaline (expanded) elsewhere, with a few scattered flocci. The gills are narrow, rather crowded, ascending, widely free on the larger specimens, but close to the stem on smaller, dry weather examples. The stalk is up to 15 cm. long, 4-10 mm. diameter at the base, strongly attenuated upwards to 1·5 to 5 mm., white, silky fibrillose below, becoming glabrous above, hollow, lined with shining white fibrils, white or brownish internally. The spores are purple black in mass, black by transmitted light, oval, somewhat inequilateral, slightly apiculate, 8-12×5-7 μ.

352.—Aecidium Chionanthi B. & Br.

This species was described by Berkeley and Broome in Fungi of Ceylon, No. 857, as "Crassiusculum, congestum; pseudoperidiis incarceratis nec prominentibus, ore irregulari; sporis candidis rugosis. On leaves of *Chionanthus*. Forming rufous thick patches; spores ·001 long with little wrinkles." The Ceylon plants included by Thwaites in *Chionanthus* are now referred to *Linociera*. In Mon. Uredinearum, VI, p. 321, Sydow stated that *Aecidium Chionanthi* is the Aecidium of *Cystopsora Oleae* Butl., the host plant having been misnamed.

Examples have been collected recently on a variety of *Olea polygama*.

The aecidia occur on the inflorescence,—on the pedicels, calyx, and corolla, all of which are enlarged and thickened. They are brownish

yellow, hemispherical or pulvinate, 0·3 mm. diameter, clustered. There is no evident pseudoperidium, the aecidium being covered by a thin membrane, glabrous and somewhat varnished, consisting of the epidermis of the host plant. This cover becomes perforated at the apex by a small pore, but in the available specimens the aecidium does not open widely.

The spores are spherical, 16-20 μ diameter, or oval, 22-28×16-17 μ, or angularly globose or oval. The contents are orange, and the wall hyaline, 2 μ thick, covered with flexuose parallel ridges, either longitudinally or obliquely, which anastomose and form a network.

353.—**Rosellinia catervaria** (B. & Br.) Sacc.

This was re-described in Ann. Perad., VI, p. 175, from the type specimen. The perithecia in the type are up to 0·4 mm. diameter. In recent collections from Hakgala, which appear to be referable to this species, the perithecia are up to 0·8 mm. diameter; they are usually clustered, sometimes confluent, at first minutely adpressed tomentose, becoming glabrous and minutely rugose. In one case, the fungus grew on dead wood, and in another, on a decaying *Fomes*. The spores in all cases are rather pale brown or pale fuliginous, oblong, or ellipsoidal, with rounded ends, centrally guttulate, 8-12×3·5-4 μ.

Berkeley and Broome gave the length of the spore as 37·5 μ.

354.—**Rosellinia rhypara** (B. & Br.) Sacc.

This was described by Berkeley and Broome in Fungi of Ceylon, No. 1106, from Thwaites 555, as "Peritheciis globosis coffeicoloribus sordidis, ostiolo minuto; ascis linearibus; sporidiis ellipticis utrinque attenuatis. On dead wood. Sporidia 22·5-25×10-12·5 μ."

There are two species in the specimen, Thwaites 555, in Herb. Peradeniya. One of them has spores, 20-28×10-14 μ, the other 11-15×7-9 μ. The former, which corresponds the more closely to Berkeley and Broome's description, is on bark. The latter, which is on dead wood, has been described as *Rosellinia albocincta* Petch, in Ann. Perad., VII, p. 300.

Rosellinia rhypara has superficial perithecia, scattered or clustered, black, globose, up to 1 mm. diameter, minutely adpressed tomentose, with a minute, conical ostiolum. The sporiferous part of the ascus is about 130×12 μ. The spores are black-brown, oval inequilateral, or cymbiform, 20-28×10-14 μ, ends obtuse, rarely slightly contracted and subapiculate.

355.—Aegerita candida P.

This was recorded for Ceylon by Berkeley and Broome in Fungi of Ceylon, No. 908, from Thwaites 285, 349, "on sticks." The specimens are on bark. Thwaites 285 also provided a *Peziza*, which Berkeley and Broome assigned to *Dasyscypha hyalina* P.

The specimens are circular, up to 0·25 mm. diameter, discoid, about 0·1 mm. thick, with a slightly convex upper surface, creamy white, and soft. They appear glabrous, but are slightly pruinose when magnified. The base is flat and the margin rounded, or sometimes the lower edge of the margin is rounded and the upper edge somewhat rectangular. Over the sides and base there is a "cortical layer," composed of radial parallel cells, about 40 μ deep, which resemble the conidiophores; these are not fused laterally and are apparently barren conidiophores. The internal tissue is plectenchymatous, composed of thick-walled irregular hyphae, and resembles the context of a tremelloid fungus, but it is not hard and horny when dry. The upper surface consists of a palisade layer of parallel basidia, about 25 μ deep. The basidia are simple, or branched near the base, stout, about 4 μ diameter, thick-walled, septate, irregular, similar to those of *Aegerita candida*. They usually bear a single apical conidium, rarely two. The conidia are oval, 6-9×4-7 μ, with a wall 1-2 μ thick; when detached they apparently remain adherent to the sporodochium.

This species resembles *Aegerita candida* in its conidiophores, and is probably to be assigned to that genus, but it is not that species. It may be known as *Aegerita discoidea*.

356.—Isaria congesta B. & Br.

Berkeley and Broome described this species, in Fungi of Ceylon, No. 861, as "Brevis, clavata, cinerea, e basi communi oriunda; sporis tenuibus oblongis (No. 78). Spores 6·25 μ long. Probably the conidioid stage of some Sphaeria."

The clavae arise in clusters of up to fifty from an erumpent stroma, which is pale yellow and somewhat loose internally, with a thin black cortex. They form spreading tufts, some lying on the surface of the host, others erect or suberect. The colour is grey or greyish brown, pale brown by transmitted light, and the individual clavae are cylindric, equal or attenuated upwards, up to 1·25 mm. high, 0·1-0·15 mm. diameter, with an obtuse apex. The outer layer is firm, but the inner tissue rather loose. They are composed of longitudinal hyphae, the tips of which curve outwards and form a loose palisade layer. These tips are clavate, up to 3 μ diameter, minutely verrucose, acute above, sometimes dividing into two or more spreading points. These bear narrow-

oval or fusoid, hyaline, continuous, minutely warted conidia, 5-8×1-1·5 μ, usually acute, both terminally and laterally.

There is no doubt that this is a stage of a stromatic Sphaeria, though it has not been possible to correlate it with any known species.

357.—**Periconia rigida** B. & Br.

This was described in Fungi of Ceylon, No. 892, as "Setiformis, e fibris plurimis compacta apice clavatis basi radiatis; sporis oblongis uniseptatis uninucleatis (No. 250)." In Saccardo, Sylloge Fungorum, IV, p. 627, it was transferred to *Didymobotryum*.

The synnemata are up to 1 mm. high, rigid, black, slightly inflated and conoid at the base to a height of about 0·2 mm., 0·18 mm. diameter below, 0·06 mm. diameter above the basal swelling, expanding above into an ovoid head, 0·25 mm. high, 0·15 mm. diameter. The conidiophores are united up to the apex. The conidia are blackish-brown; oblong-oval or narrow oval, ends usually rounded, one-septate, sometimes slightly constricted, 10-16×4-6 μ. The type specimen is on bamboo.

This does not appear to differ from *Didymobotryum atrum* Pat., the conidia of which are given as 16-18×6 μ.

358.—**Sporotrichum lichenicola** B. & Br.

Berkeley and Broome described this, in Fungi of Ceylon, No. 916, as "Niveum, floccis erectis acutis; sporis oblongis apicalibus (No. 430). On lichens."

The plant forms minute, lax, white tufts, up to 0·2 mm. high, each composed of a few (up to six), erect or spreading, rigid, moniliform chains of cells, which branch dichotomously. In general appearance it resembles a minute coralline. The cells are oval, truncate at the ends, 22-26×16-20 μ, not separating, strongly encrusted with minute spherical granules which do not dissolve in hydrochloric or sulphuric acid.

If this is really a fungus it is a *Moniliopsis*.

359.—**Fusarium pulvinatum** (B. & Br.) Sacc.

This was described by Berkeley and Broome, in Fungi of Ceylon, No. 917, as *Fusisporum pulvinatum* B. & Br., "Eximie pulvinatum, pallidum, tomentosum; sporis curvulis elongatis triseptatis (No. 215). On bark. November, 1867." In Saccardo, Sylloge Fungorum, IV, p. 699, it was transferred to *Fusarium*.

The specimens are on the thin outer layer of the bark, which was evidently readily separable from the underlying tissue. They are flattened pulvinate, up to 4 mm. diameter and 1 mm. high, sometimes

arranged in rows. The surface is at first glabrous and nodular, but subsequently becomes tomentose or strigose with rather thick masses of coarse, intertwined, somewhat rigid hairs. When sectioned, the cushion is friable, and breaks up into coarse granules. Beneath each cushion, the bark is either elevated gradually in a convex blister, or grows out into a subglobose hollow structure, open at the base.

The context of the cushion is composed of thin-walled, irregular fibres, up to 16 μ diameter, which appear to be part of the host plant. The hairs are 6·10 μ diameter, minutely verrucose, regular, and resemble stout hyphae. They do not give the cellulose reaction with chlor-zinc-iodide, nor the lignin reaction with phloroglucin.

The spores described by Berkeley and Broome have not been observed, and it would seem doubtful that they could have belonged to the cushions. Until fresh material has been collected, it would be unsafe to arrive at any conclusion concerning these specimens, but there appears to be a strong probability that they are a gall formation. The remains of mites are common among the hairs, but that may be accidental.

360.—**Psilonia penicillata** B. & Br.

Berkeley and Broome described this, in Fungi of Ceylon, No. 915, as "Nivea, e communi basi penicillata, apicibus inflatis; sporis minutis (No. 225). On leaves apparently of some palm. Spores 0·0001 long. Analogous to *Fusidium fasciculatum*." In Saccardo, Sylloge Fungorum, IV, p. 689, it was transferred to *Volutella* as *Volutella penicillata* (B. & Br.) Sacc.

The fungus forms minute, white, obconic tufts, plentifully scattered over the host, and now generally lying flat in small fans on the substratum. They are 0·3-0·5 mm. high, 20-100 μ diameter at the base, expanding to a breadth of 300 μ at the apex, and are composed of diverging conidiophores which are sometimes more or less massed into a columella in the centre. The individual conidiophores are hyaline, somewhat rigid, thick-walled, closely septate above, 3-4 μ diameter below, the apical segment oval and expanding to 6 μ diameter. The conidia are borne on minute sterigmata in a ring below each septum, and at the apex, and are hyaline, oval, verrucose, 3-4×2·5-3 μ, or globose, 3·5 μ diameter. Frequently the sterigmata arise from a thickening of the wall, about 2·5 μ long and 1·5 μ high at one side of the conidiophore or at the apex.

The conidiophore and conidia of this species are identical with those of *Isaria pulcherrima* B. & Br. (Fungi of Ceylon, No. 863); and there is no doubt that it is a young or a reduced form of the latter species.

361.—Penicillium incarnatum B. & Br.

This was described by Berkeley and Broome in Fungi of Ceylon, No. 910, as "Pulvinulis minutis pallide carneis; floccis articulatis erectis hyalinis, apice digitatis; sporis limoniformibus (No. 241). On leaves of some Monocotyledon. Spores 0·0003 long."

The fungus is on a bamboo stem. It is erumpent, raising and cracking the epidermis in a minute oval scale, up to 0·3 mm. long and 0·15 mm. broad, the fungus appearing usually at one edge of the scale in a compact, pinkish, linear tuft, generally not more than 0·1 mm. high. The conidiophores are crowded, hyaline, stout, about 6 μ diameter below, sparingly branched above, the branches being about 4 μ diameter and forming a head about 40 μ high. The phialides are narrow-oval, 10-12×3 μ, three or four at the apex of each branch. The conidia are hyaline, oval, very minutely warted, 4-7×2·5-3·5 μ.

This species has not been collected again.

362.—Fusidium Crataevae B. & Br.

This species was described by Berkeley and Broome in Fungi of Ceylon, No. 880, as "Niveum, minutum, floccis brevibus nodulosis; sporis clavaeformibus basi attenuatis (No. 512). On leaves of *Crataeva Roxburghii*. Peradeniya. February, 1868. Spores 0·002 long." In Saccardo, Sylloge Fungorum, IV, p. 27, the note is added "An *Heliscus*?"

The lower surface of the leaf, in the type specimen, is elevated in minute flattened tubercles, up to 0·3 mm. diameter, crowded together in patches up to 1 cm. diameter, on extensive brown discoloured areas. These tubercles are covered by a white network of hyaline hyphae, 4 μ diameter, which are most numerous between the tubercles. The hyphae bear solitary conidia, almost sessile, laterally. The conidia are hyaline, clavate or narrow flask-shaped, truncate at the base, strongly attenuated in the upper half, three septate in the lower half, 36-68 μ long, 6 μ diameter below, 3 μ diameter above, apex obtuse.

This appears to be a *Cercosporella*, and will stand as *Cercosporella Crataevae* (B. & Br.).

363.—Fusidium fasciculatum B. & Br.

Berkeley and Broome described this species in Fungi of Ceylon, No. 879, as "Album, erectum, floccis fasciculatis saepe connatis; sporis oblongis (No. 142). Forming little white scattered tufts on bark. Spores 0·0006 long." In Fungi of Ceylon, No. 915, they described *Psilonia penicillata* B. & Br., and stated that the latter was analogous to *Fusidium fasciculatum*.

The specimens of *Fusidium fasciculatum* are on a dead twig and are in poor condition, apparently weathered. They are the same as *Psilonia penicillata* B. & Br., i.e., they are a reduced form of *Isaria pulcherrima* B. & Br. Spores 15 μ long have not been found; this measurement appears to be that of the terminal segment of the conidiophore.

364.—**Penicillium roseum** Link.

This species was recorded for Ceylon by Berkeley and Broome in Fungi of Ceylon, No. 911, on *Hibiscus*. No Thwaites' number was cited, the specimen having been sent by him in 1850.

The leaf bears minute, powdery, or somewhat byssoid, pink patches. These bear one-septate spores and are evidently not *Penicillium*. The conidiophores are 2-3 μ diameter below, dividing irregularly into finer branches above, and bearing branched chains of conidia, terminally and laterally. The conidia are hyaline, narrow-oval, one-septate, ends acute, 5-7×2-3 μ. This appears to be a *Hormiactis*, though the conidiophore is not simple and regular, as described for the type of that genus. It may be known as *Hormiactis rosea*.

Hormiactis rosea Petch, n. sp. Forming minute, powdery, pink patches; conidiophores hyaline, 2-3 μ diameter below, dividing irregularly above into finer branches; conidia in terminal or lateral branched chains, hyaline, narrow-oval, one-septate, ends acute, 5-7×2-3 μ.

365.—**Cladosporium herbarum** Lk. var. **torulosum** B. & Br.

This variety was described by Berkeley and Broome in Fungi of Ceylon, No. 886, as "Floccis erectis torulosis; sporis dein uniseptatis. On leaves of *Anamirta*. Spores 0·0003-0·0005 long."

The fungus forms small black-brown patches on the under surface of the leaf. The conidiophores are dark-brown, up to 300 μ high, 4 μ diameter, slightly inflated at the base. In some instances they are inflated to 6 μ diameter just below a septum, but this is not universal. The conidia are oval, 5-10×3-7 μ, or subglobose, 4 μ diameter, or oblong-oval, one-septate, constricted or not, 12-16×5-6 μ, or cylindric, two-septate, 26×6 μ.

This inflation of the conidiophore is of common occurrence in species of *Dematiae*, and it is not feasible to make a variety on this character only.

366.—**Helminthosporium gigasporum** B. & Br.

Berkeley and Broome's description of this species, in Fungi of Ceylon, No. 882, is "Flocci simplices obtusi; sporis maximis, hic trun-

catis, illic attenuatis, apice hyalinis, multiseptatis (No. 246). On wood. Spores 0·0045 long."

The specimen, Thwaites 246, in Herb. Peradeniya, is on a dead stem. The conidiophores are erect, simple, rigid, up to 1 mm. high, 20 μ diameter below, attenuated to 12 μ above, black-brown, and arise singly, or fasciculate in small clusters, close together, forming a dense pile extending over several centimetres. In this specimen the available conidia are 100-130 μ long, narrow flask-shaped, or clavate with a long cylindric tip, 20 μ diameter below, 5 μ diameter above, attenuated in the upper third, 10-14-septate, very thick-walled; the tip may be straight or curved. In a specimen on tea from Pambagama (No. 5737, June, 1918), the conidia are up to 300 μ long, the basal clavate part about 60 μ long and the cylindrical tip, 240 μ long, 4-5 μ diameter; in this specimen the wall and septa are thinner than in the type.

367.—**Helminthosporium atropurpureum** B. & Br.

This was described by Berkeley and Broome in Fungi of Ceylon, No. 884, as "Effusum, atropurpureum, floccis erectis apice clavulato-divisis; sporis oblongis triseptatis. On smooth bark, Nov. 1867. Spores 0·001-0·0013 long."

The type specimen is in bad condition; it is apparently on some Malvaceous plant. The conidiophores are in clusters of about a dozen, simple, rigid, up to 200 μ high, 8 μ diameter below, slightly attenuated upwards, purple brown, septate. The conidia are cylindric, almost equal, dark brown, three-septate, not constricted, minutely warted, one end rounded, the other truncate, 20-28 × 5 μ.

368.—**Helminthosporium Arecae** B. & Br.

This species was described by Berkeley and Broome in Fungi of Ceylon, No. 883, as "Pulvinulis mollibus e fibris radiantibus; sporis magnis obovatis 3-septatis (No. 164). Forming little patches on the leaves of *Areca Catechu*. Spores 0·002-0·0023 long. Sometimes the spores are more than triseptate, when they are much attenuated below."

The specimen in Herb. Peradeniya is marked "on leaves of palms." The fungus forms black superficial pulvinate stromata up to 0·6 mm. diameter, from which hyphae radiate over the surface of the leaf and form a network about 0·2 mm. wide. The base of the stroma is pseudo-parenchymatous. The repent hyphae are about 3 μ diameter, irregularly contorted, often united laterally into broad strands. The stroma is densely covered with erect, dark-brown, rigid, thick-walled conidiophores, up to 200 μ high, 6 μ diameter below, expanding to 12 μ dia-

meter above. The conidia are 46-56 μ long, very variable in shape; some are obclavate, 46×14 μ, others broadly flask-shaped, 48×20 μ, and others broadly oval with an attenuated apex. In the latter the basal part is 32-42×20-26 μ, and the attenuated apex, 16-20×4-6 μ. The spores are three to four septate, truncate at the base, often with the lowest cell but one darker than the others.

This appears to be closely similar to *Exosporium megalosporum* Penz. and Sacc., but the spore measurement given for the latter species is larger (100-150×15-16 μ). It may be known as *Exosporium Arecae* (B. & Br.).

369.—Helminthosporium calicioideum B. & Br.

This species was described by Berkeley and Broome in Fungi of Ceylon, No. 881, as "Caespitosum, congestum, fastigiatum; sporis sursum truncatis, deorsum attenuatis, multiseptatis (No. 151). On wood. Look at first like a *Calicium*. Spores 0·003-0·004 long."

The specimens are on a dead herbaceous stem. They are erumpent, with a short, stout glabrous stalk, up to 0·4 mm. diameter and 0·3 mm. high, which expands abruptly into a discoid head, up to 1 mm. diameter. The head is purple brown, and in the larger type specimens is now flattened, no doubt through pressure in drying, as the conidiophores are depressed. The stalk is embedded in the host tissue to a depth of 0·5 mm., the embedded part being of the same diameter as the external part. The whole length of the stalk is composed of fused longitudinal hyphae, which, in the embedded portion, are hyaline in thin sections. These hyphae separate above, and form a head of somewhat flexuose, purple, thick-walled conidiophores, 6 μ diameter.

The conidia vary in length from 56 to 108 μ, and in diameter from 12 to 16 μ. The shorter are clavate or fusoid or subcymbiform; the larger are clavate, with an attenuated apex up to 30 μ long, 4-8 μ diameter. They are pale fuscous or pale purple grey, thick-walled, 8 to 15 septate, straight, curved, or flexuose.

As this species forms synnemata, it should be referred to *Podosporium*, as *Podosporium calicioideum* (B. & Br.).

As in their description of *Helminthosporium Arecae*, Berkeley and Broome regarded the apex of the spore as the base.

370.—Isaria congregata B. & Br.

The original description of this species, in Fungi of Ceylon, No. 862, is "Congesta, clavaeformis, fusca, capitulis pallido-umbrinis; sporis elongatis, sursum obtusis, deorsum acuminatis (No. 140). On wood,

Nov., 1861. Densely crowded: flocci towards the upper joints with the articulations deeply indented; spores 0·0006 long. Possibly a state of some *Sphaeria*."

On the specimen in Herb. Peradeniya, the synnemata arise from the blackened wood or the bark in small clusters. They are connate at the base, sometimes springing from a small pulvinate stroma, purple brown, diverging, subcylindric, attenuated upwards, up to 2 mm. high, 60-100 μ diameter, composed of parallel hyphae which separate as conidiophores above, the stalk tomentose with diverging conidiophores here and there. The conidiophores are 3 μ diameter, branched above, each branch terminating in a cluster of phialides, like a *Penicillium*. The phialides are narrow flask-shaped, or subcylindric, 12-16 μ long, inflated at the apex. The hyphae of the stalk are red-brown by transmitted light, the free conidiophore pale fuscous or almost hyaline. The conidiophores and phialides are everywhere minutely verrucose. The conidia are oval, pale fuscous or almost hyaline, minutely warted, 3-6×2-2·5 μ. From the inflated apex of the phialide, it would appear that each bears several conidia. It is not possible to say whether they are in chains or not from the specimen, but it would appear probable that they are not.

On the old classification, this species should have been placed in *Graphium*, not in *Isaria*. The conidiophore, however, appears to be different from that of any described species. As suggested by Berkeley and Broome, it is probably the conidial stage of a pyrenomycete.

One piece of Thwaites 140 bears, in addition to *Isaria congregata*, a byssoid stroma composed of somewhat rigid, brown hyphae, 4 μ diameter, which branch dichotomously. This does not appear to be related to the *Isaria*.

371.—Oedemium sparsum B. & Br.

This species was described by Berkeley and Broome in Fungi of Ceylon, No. 903, as "Floccis subramosis hic illic processus hyalinos sporas fusiformes gerentes emittentibus (No. 431). On *Pandanus odoratissimus*. Sometimes divided at the apex in a radiating manner. Spores 0·001 long."

In Thwaites 431 in Herb. Peradeniya, the synnemata are scattered, black, rigid, subulate, inflated at the base to 100 μ diameter, 50 μ diameter above the inflation, attenuated to 24 μ at the apex. They are composed of parallel hyphae, a few of which diverge at different heights as simple, rigid, somewhat recurved, irregularly geniculate conidiophores, up to 64 μ long, 4 μ diameter, reddish-brown, hyaline at the apex. The apex of the synnema divides into a few similar conidiophores. The conidia are narrow-oval or subcylindric, rounded at one end, sub-

acute at the other, straight or slightly curved, 3 to 5 septate, slightly constricted at the septa, pale fuscous, 24-32×6-8 μ.

Very few attached conidia are now present. Numerous other *Dematiae* occur on the specimen, the most abundant conidium being spherical, black-brown, strongly verrucose, 10-12 μ diameter. The septate spore has, however, been found attached, and it is apparently the spore measured by Berkeley and Broome. The fungus is a *Podosporium*, and will stand as *Podosporium sparsum* (B. & Br.).

372.—Fusidium pulvinatum B. & Br.

This species was described by Berkeley and Broome in Fungi of Ceylon, No. 878, as "Candidum, pulvinatum, sporis cylindricis (No. 166). On dead stems of herbaceous plants. Spores 0·0004 long."

The fungus forms small, irregularly pulvinate, waxy looking masses, up to 0·3 mm. long and 0·2 mm. diameter, gregarious in small patches and united by narrow waxy bands, or by strands of mycelium. Examination shows that it is a *Clonostachys*, the conidiophores and conidia adherent in a continuous mass.

The conidiophores are short, about 80 μ high, branched in the upper 60 μ. The stem is stout, 4 μ diameter, and the branches thinner, 2 μ diameter. The ultimate branches, with their adherent conidia, are up to 30 μ long and 6-9 μ diameter. The conidia are hyaline, continuous, oblong with rounded ends, 4-6×2-3 μ.

This may be known as *Clonostachys pulvinata* (B. & Br.).

373.—Stilbum compressum B. & Br.

Berkeley and Broome described this species, in Fungi of Ceylon No. 867, as "Congestum, albidum, stipite compresso; sporis subellipticis (No. 742). On decaying fruit of *Citrus decumana*, crowded like the prickles of an *Irpex*; spores 0·0002 long."

The synnemata are gregarious, sometimes fasciculate and connate at the base, subtranslucent, up to 0·7 mm. high. The stalk is about 0·4 mm. high, laterally compressed, 0·2 mm. broad, clothed with loose longitudinal hyphae. The head is up to 0·4 mm. broad, 0·3 mm. high, sometimes lobed. The conidiophores bear whorls of phialides towards and at the apex, the phialides being narrow flask-shaped, 8-12 μ long, 1·5 μ diameter below. The conidia are hyaline, oval, or oblong-oval, ends rounded, 4-5×2-2·5 μ. Chains of conidia have not been observed, but it is most probable that the fungus is a *Coremium*. It may stand as *Coremium compressum* (B. & Br.).

Thwaites 742 also includes a hyphomycete which grows in minute white tufts.

374.—Aegerita mellea B. & Br.

The original description of this species, in Fungi of Ceylon, No. 909, is "Minuta, subglobosa, mellea (No. 1019). On lichens. Peradeniya, Dec., 1868. Small yellow tremelloid specks scarcely visible without a lens."

The sporodochia are now translucent amber, flattened pulvinate, up to 0·2 mm. long, 0·1 mm. broad, or subglobose, 0·15 mm. diameter. They are superficial, scattered or clustered. The conidiophores are irregular, about 5 μ diameter, and terminate in hyaline, smooth pseudoconidia, either broadly oval or globose, 10-16×7-12 μ. The pseudoconidia may be in chains of two, or a pseudoconidium may bear a terminal cluster of two or three.

375.—Psilonia gilva Fr.

This species was recorded for Ceylon by Berkeley and Broome in Fungi of Ceylon, No. 914, from Thwaites 257.

The specimen in Herb. Peradeniya bears tawny brown, effused, minutely tomentose, thin patches, a few millimetres long and broad, which become blackish brown when old. The older patches are readily separable from the substratum. The basal hyphae, in the younger stromata, are hyaline, up to 4 μ diameter, and give off branches, some with clavate or lobed spinulose tips up to 4 μ diameter, others curved, slender, 1 μ diameter, which intertwine and form the context of the stroma. In the older stromata the hyphae are yellow-brown, chiefly longitudinal, running parallel to one another over the bark, 4 μ diameter at the septa, often inflated to 6 μ in the middle of a segment. These hyphae bear sessile, oval, yellow-brown, spinulose conidia, about 4×3 μ, laterally.

This is probably an immature example of a basidiomycete. It is certainly not *Volutella gilva* (Pers.) Sacc.

376.—Hymenopsis atrocarneum (B. & Br.) Sacc.

This species was described by Berkeley and Broome in Fungi of Ceylon, No. 1207, as *Myrothecium atrocarneum*, "Disco atro, deplanato, e massa carnea oriundo; sporis ellipticis (No. 167). Spores 0·003 long." It was transferred to *Hymenopsis* in Saccardo, Sylloge Fungorum, IV, p. 747.

The sporodochia are erumpent, at first almost plane, becoming convex, irregularly circular or oval, up to 1 mm. diameter, attached

over about half the base, without differentiated margin. In the herbarium specimens they are orange, sub-translucent, becoming black from the centre outwards. Only the mass of conidia becomes black. The conidiophores form a dense palisade layer, and are about 24 μ high, the lower half being simple, cylindric, 2 μ diameter, and bearing at its apex about four narrow flask-shaped phialides, 1·5 μ diameter. The conidia are oblong-oval, pale fuscous, 5-7 × 2·5-3 μ; they remain adherent in chains.

377.—**Myrothecium Carmichaelianum** Grev.

This was recorded for Ceylon by Berkeley and Broome in Fungi of Ceylon, No. 872, from Thwaites 1049. According to Saccardo, the name should have been *Myrothecium Carmichaelii* Grev., which is *Myrothecium roridum* Tode.

The sporodochia are thin, flat, adnate, black, either circular, about 0·4 mm. diameter, or forming irregular patches, up to 1·5 × 1 mm., without differentiated margin. The herbarium specimens have white floccose patches on the sporodochia, but these are an adventitious hyphomycete. The conidiophores are simple, subcylindric, attenuated upwards, about 12 μ long, 2 μ diameter. The conidia are green in mass by transmitted light, greenish fuscous individually, narrow oval, one end acute, the other slightly constricted and papillaeform, 6-8 × 2-3 μ.

This species is a *Hymenopsis*. Its conidia differ from those of *Myrothecium roridum*, and it has no white margin. It may be known as *Hymenopsis tenuis* n. sp.

378.—**Anthina cinnabarina** B. & Br.

This species was described by Berkeley and Broome in Fungi of Ceylon, No. 873, as "Compressa, parce ramosa, sursum sporis minutissimis albis tecta (No. 41). Amongst fragments of plants. Sometimes forked: a few slender threads accompany it, which are perhaps imperfectly developed conidiophora. Spores globose, too minute to measure."

The specimens of Thwaites 41 in Herb. Peradeniya are on fragments of a cocoon, and the fungus is most probably the *Isaria* of *Cordyceps coccinea* Penz. and Sacc.

379.—**Stilbum clavula** B. & Br.

This species was described by Berkeley and Broome in Fungi of Ceylon, No. 870, as "Clavatum, intus cellulosum, e materie nigra oriundum, sursum cinereum, deorsum, nigrum; sporis oblongis obtusis (No. 150). On bark, etc. Nov., 1867. Spores 0·0005 long."

In Fungi of Ceylon, No. 869, Berkeley and Broome recorded *Stilbum byssigena* B. & Br., for Ceylon, the name being a substitution for *Stilbum byssisedum* B. & C., described from Cuba. The Ceylon specimen was Thwaites 123, and its spores were said to be fusiform, 0·0005-0·0006 long by 0·0002.

The two Ceylon specimens, Thwaites 123 and 150, are the same species, 150 being a young stage. The young specimens in Thwaites 123 exactly match Thwaites 150.

The young specimens are up to 1·2 mm. high, slightly expanded at the base, 0·1 mm. diameter below, clavate, expanding uniformly upwards into an ovoid head 0·3 mm. diameter, dark-brown, pruinose.

They are white internally, with a brown outer layer, soft, not carbonaceous. They are composed of longitudinal hyphae, some of which are up to 7 μ diameter and have contents which stain brownish yellow with iodine. The head bears a palisade layer of cylindric or clavate conidiophores, 16 μ high, 4 μ diameter. The conidia are narrow oval, oblong-oval, or fusoid, one or both ends acute, 9-12×2·5-4 μ, hyaline.

The larger specimens have a stalk up to 0·3 mm. diameter, purple-brown, minutely tomentose, irregularly fluted, expanding abruptly into a subglobose, brown, tomentose head, up to 1 mm. diameter. These specimens show a peripheral layer of developing perithecia.

The wood may be covered by a thin byssoid layer, or may be merely blackened.

These are developing clavae of some Xylariaceae. The Cuban fungus, which is the type of *Stilbum byssigenum* B. & Br., has not been examined.

NAME INDEX

Aecidium Chionanthi B. & Br. 166
Aegerita candida P. 168
Aegerita discoidea Petch 168
Aegerita mellea B. & Br. 177
Anthina cinnabarina B. & Br. 178

Cercosporella Crataevae (B. & Br.) Petch 171
Cladosporium herbarum Lk. var. torulosum B. & Br. 172
Clonostachys pulvinata (B. & Br.) Petch 176
Coprinus castaneus B. & Br. 166
Coprinus setulosus B. & Br. 165
Cordyceps coccinea Penz. & Sacc. 178
Coremium compressum (B. & Br.) Petch 176
Crepidotus epicrocinus B. & Br. 164
Cystopsora Oleae Butler 166

Didymobotryum atrum Pat. 169
Didymobotryum rigidum (B. & Br.) Sacc. 169

Exosporium Arecae (B. & Br.) Petch 174
Exosporium megalosporum Penz. & Sacc. 174

Fusarium pulvinatum (B. & Br.) Sacc. 169
Fusidium Crataevae B. & Br. 171
Fusidium fasciculatum B. & Br. 171
Fusidium pulvinatum B. & Br. 176
Fusisporium pulvinatum B. & Br. 169

Helminthosporium Arecae B. & Br. 173
Helminthosporium atropurpureum B. & Br. 173
Helminthosporium calicioideum B. & Br. 174
Helminthosporium gigasporum B. & Br. 172
Hormiactis rosea Petch 172
Hymenopsis atrocarneum (B. & Br.) Sacc. 177
Hymenopsis tenuis Petch 178

Isaria congesta B. & Br. 168
Isaria congregata B. & Br. 174
Isaria pulcherrima B. & Br. 170

Mycena clavulifer B. & Br. 162
Mycena corticola Schum. 163
Mycena dendrophila Petch 164
Mycena heliscus B. & Br. 163
Mycena paediscula B. & Br. 162
Mycena tenerrima Berk. 161
Myrothecium atrocarneum B. & Br. 177
Myrothecium Carmichaelianum Grev. 178

Oedemium sparsum B. & Br. 175

Penicillium incarnatum B. & Br. 171
Penicillium roseum Link. 172
Periconia rigida B. & Br. 169
Podosporium calicioideum (B. & Br.) Petch 174
Podosporium sparsum (B. & Br.) Petch .. .. ..
Psathyrella ctenodes B. & Br. 164
Psathyrella disseminata P. 164
Psilonia gilva Fr. 177
Psilonia penicillata B. & Br. 170

Rosellinia albocincta Petch 167
Rosellinia catervaria B. & Br. 167
Rosellinia rhypara B. & Br. 167

Sporotrichum lichenicola B. & Br. 169
Stilbum byssigenum B. & Br. 179
Stilbum clavula B. & Br. 178
Stilbum compressum B. & Br. 176

Volutella gilva (Pers.) Sacc. 177
Volutella penicillata (B. & Br.) Sacc. 170

The Fungi associated with disease in Vanilla

BY

T. Petch

Director, Tea Research Institute, Ceylon

AND

C. Ragunathan

Assistant to the Mycologist, Dept. of Agriculture, Ceylon

WITH TWO PLATES

The first record of a disease of Vanilla (*Vanilla planifolia* Andr.) was made by Cooke in 1886. He had received specimens from Antioquia, Colombia (South America), and on these he found two fungi which he described as *Uredo scabies* and *Gloeosporium Vanillae* respectively. Cooke ascribed the disease to the *Uredo*, which he stated appeared to be very destructive and was regarded as a pest by the cultivators. The habit of the *Uredo* was said to be peculiar and characteristic, giving the leaves a scabby appearance, and in the description of the fungus it was stated that the spots which it caused were bullate, and surrounded by a black line. This effect of the *Uredo* on the leaf differs from that of the other fungi recorded on Vanilla. As a rule, the internal tissue decays and shrinks, leaving the epidermis or the cuticle as a thin grey persistent membrane, often free from the underlying decayed tissue.

In 1891, Massee published an account of his investigations of a disease of Vanilla which occurred in the Seychelles, Mauritius, and Réunion. No field notes on the disease of that date are available, except that the pods turned black at either end or in the centre, and dropped off in the course of a day or two. Massee mentions that some of the living leaves when received at Kew bore minute, dull red or amber pustules on slightly discoloured patches. He found, or developed on his specimens, three fungi, a *Hainesia*, a *Cytospora*, and a *Calospora*, which he regarded as stages of the same species, *Calospora Vanillae* Massee.

Massee also stated that these three fungi were present on Cooke's specimens from Antioquia (Antigua in error, in Kew Bulletin, 1892, p. 120), and that *Gloeosporium Vanillae* Cke. was identical with the form he assigned to *Hainesia*. Cooke, however, gave the spores of *Gloeosporium Vanillae* as 18-25 × 5–6 μ, while Massee described the spores of his *Hainesia* as "constant in form and size, measuring 9–10 × 3·5–4 μ".

Massee recorded that all the stages of the disease had been followed at Kew, on cultivated orchids belonging to the genera *Oncidium* and *Dendrobium*.

In 1895, Hennings received a diseased Vanilla pod from the Cameroons, and after summarising Massee's account of the Vanilla disease of the Seychelles, stated that the Cameroon specimen was apparently attacked by the same fungus. He also recorded the receipt of diseased Vanilla leaves from Mexico, on which he found a Stictideae, *Ocellaria Vanillae*, and a *Gloeosporium* which he considered different from *Gloeosporium Vanillae* and named *Gloeosporium Bussei*. The *Ocellaria* was said to be very injurious, and the *Gloeosporium* most probably as destructive as *Gloeosporium Vanillae*.

Hennings further recorded that *Gloeosporium affine* Sacc. often attacked the leaves of Vanilla plants in the green-houses of the Berlin Botanic Gardens, causing black spots which ultimately spread over the whole leaf and killed it.

Miss Stoneman, in 1898, published a description of *Gnomoniopsis Vanillae*. This had been found on leaves of a cultivated species of *Vanilla* in North America, presumably a green-house plant. Its conidial stage was a *Colletotrichum*.

In 1902, Delacroix summarised the information then existing concerning the species of *Gloeosporium*, etc., on Vanilla, and added further observations of his own. Nine years previously, he had received specimens of diseased Vanilla from Réunion, and had found on them a fungus which he described as *Vermicularia Vanillae*. In 1900, he received further specimens from Grand Comoro and from Madagascar, and in 1901 from Tahiti ; and after a study of these he arrived at the following conclusions:—

Gloeosporium Vanillae Cke. may be either *Gloeosporium* or *Colletotrichum*. In some cases it forms a pycnidium, which may be correspondingly either a *Phoma* or a *Vermicularia*. It was the latter which was described as *Vermicularia Vanillae*, while the former constituted Massee's *Cytospora*, which, from the description and figure, was evidently not a *Cytospora*. *Gnomoniopsis Vanillae* Stonem. was immature *Calospora Vanillae*.

It is to be noted that Delacroix found *Calospora Vanillae* on his specimens. He stated that it was not so deeply immersed as shown by Massee, and that the ostiolum was only feebly coloured. He did not carry out infection experiments with the ascospores, because no Vanilla was available for infection at the time when the ascospores were mature.

Saccardo, in Sylloge Fungorum, III, p. 709, had enumerated *Gloeosporium affine* Sacc., as occurring on *Hoya* and Vanilla at Padua, and on leaves of orchids at Dresden. Delacroix obtained examples of the Dresden fungus and of that on Vanilla, parts of Saccardo's specimens, and found that these were different species, the Vanilla specimen being identical with *Gloeosporium Vanillae*. Hence Delacroix concluded that *Gloeosporium affine* Sacc., in so far as it related to the species on Vanilla, was identical with *Gloeosporium Vanillae* Cke.

In the same paper, Delacroix described a *Uromyces*, on Vanilla from Tahiti, as *Uromyces Joffrini*. This occurred on the same pods as *Gloeosporium Vanillae*.

Zimmermann, also in 1902, published a paper on some diseases of Vanilla in Java, one of which was apparently the common Anthracnose or Soft Rot. It attacked the stems, and more rarely the leaves. The stems became pale brown and then dark brown to black, while the tissues ultimately shrivelled and dried up. On the old diseased stems yellowish-white acervuli appeared, which Zimmermann considered to be a *Colletotrichum*, and these were followed by a *Nectria*, *Nectria Vanillae* Zimm. Zimmermann apparently regarded these as stages of the same fungus, and the cause of the disease. Among other fungi described in the same paper were *Nectria peristomata* Zimm. and *Physalospora Vanillae* Zimm., the latter on decaying leaves.

In the same year, Hennings described from Java, *Nectria vanillicola* and *Phyllosticta Vanillae*. According to von Höhnel and Weese, *Nectria Vanillae* and *Nectria vanillicola* are forms of *Nectria tjibodensis* Penz. and Sacc.

In 1903, Hennings received diseased fruits of Vanilla from East Africa (Dar-es-Salam), and described another fungus, *Trullula Vanillae*, as the cause of the disease.

Scalia, in 1903, published a description of *Colletotrichum Vanillae* Scalia, which was found on leaves of Vanilla in the Botanic Garden at Catania, Sicily.

In 1907, Bernard examined diseased plants of Vanilla in Java and found on them a *Nectria*, which he described as *Nectria bogoriensis*. The specimens were old, and he was unable to decide whether the *Nectria* was the probable cause of the disease. Von Höhnel and Weese state

that *Nectria bogoriensis* Bern. is a form of *Nectria Bolbophylli* P. Henn. In that case, it is *Nectria haematococca* B. & Br., one of the commonest saprophytic Nectrias of the eastern tropics.

It may be noted that in some instances the fungi mentioned above have been recorded as occurring on *Vanilla odorata*. That is doubtless a mistake for *Vanilla planifolia*, the species usually cultivated as Vanilla (excluding Vanillons). All that is known of *Vanilla odorata* Presl is the original description.

In 1912, Maublanc published a summary of the different accounts of the fungi which had been described on Vanilla. This is practically the same, as regards its conclusions, as that of Delacroix ten years previously. Maublanc stated that *Gloeosporium Vanillae* Cke. develops setae and is then probably identical with *Colletotrichum Vanillae* Scalia. Moreover, instead of the open or flat fructification of the typical *Melanconiaceae*, the fungus may produce true pycnidia, either scattered or in groups. In that case, if setae are developed, it appears to be a *Vermicularia*, while if setae are absent it is a *Macrophoma*. When the *Macrophoma* pycnidia are grouped, the fructification resembles *Dothiorella*, and it was certainly this form, according to Maublanc, which Massee referred to *Cytospora*. Maublanc also suggests that the fungus which Zimmermann regarded as a *Colletotrichum* belonged to the *Tuberculariaceae*.

Shear and Wood, in 1913, in their investigation of the genus *Glomerella*, obtained diseased leaves of Vanilla from Florida. These bore acervuli in which setae were present in some cases but not in others. Plates were poured, using conidia from these acervuli. "Acervuli soon developed on the poured plates and four subcultures were made in tubes. Acervuli soon developed in the tubes but their number, size, and distribution varied greatly. In one tube there was only one large acervulus, in another the surface of the medium was thickly dotted with acervuli with pinkish spore masses. In some of the tubes the mycelium remained whitish, in others it became quite dark-coloured. The variations in amount and colour of the mycelium, and in the number, size, and distribution of the acervuli were very striking. No perithecia or perithecium-like bodies were found in any of these cultures. The conidia from the leaves ranged from 13·5 to 24 by 4·5 to 6 μ. There are no sufficient morphological characters to distinguish this fungus from that found on the grape and apple, *Gloeosporium rufomaculans* (Berk.) Thuem. It has, therefore, been referred to the same species, *Physalospora Vanillae* A. Zimm. is apparently the perithecial form." Setae were not found in culture.

In 1916, Meinecke published a report on Vanilla in Tahiti and Moorea. The principal disease, "La *Maladie* tout court des planteurs" was said to be Anthracnose, but the report does not add anything to our knowledge of the fungi or of the field characters of the disease.

VANILLA DISEASE IN CEYLON

The common Vanilla disease in Ceylon begins with the south-west monsoon rains about the middle of May and continues until about the end of August. August and September have usually a low rainfall. It becomes common again about the middle of October, when the north-east monsoon rains begin, and is checked by the dry weather in January.

The first sign of the disease is a yellowing of parts of the stem or the leaves. On the stem this usually begins either at the base of the stem, which is not necessarily in contact with the ground, or at a node; on the leaf it may originate at the tip or in the middle of the leaf. If the weather conditions become unfavourable for the development of the disease, it remains in this stage, sometimes for several weeks, until a wetter period sets in. The yellow areas then turn chocolate brown, and in a week or ten days become covered with pink masses.

The leaf is attacked from the base, only when the disease passes from the stem to the leaf. On the other hand, in almost all the cases noted, the disease, when it begins on a leaf, does not travel from the leaf to the stem. Consequently it is quite common to see healthy stems with diseased dry leaves hanging on them. From these facts, there would seem to be a possibility that two fungi may be concerned in these effects.

The decayed leaves generally remain entire and attached to the stem, and dry up when the rains cease. They are then grey, the strong epidermis being longitudinally wrinkled owing to the shrinkage of the internal tissue. Decayed stems, on the other hand, are usually converted into a bundle of loose fibres.

The disease is a typical soft rot, though, owing to the thick epidermis of the plant, that may not be apparent from dried specimens. It is evident from the descriptions that the common disease of Vanilla in every Vanilla-growing country exhibits similar symptoms.

Four fungi have been found to occur regularly on Vanilla attacked by soft rot in Ceylon. These have been studied in pure culture from single spores and are described below. The practical work has been carried out by the junior author.

Species A.

This species was first observed in the perithecial stage on Vanilla attacked by soft rot which had been washed with 0·1 per cent mercuric chloride and kept in a glass dish. Cultures started with ascospores yielded the conidial stage. Subsequently both stages were identified on Vanilla soft rot specimens kept in glass dishes, and on diseased specimens in the field. In the latter case the fungus was found only on the stems.

The perithecia (Plate III, figs. 1, 2) are usually clustered, globoso-conoid or flask-shaped, 280–350 μ high, 245–280 μ diameter. In the flask-shaped examples, the neck may be up to 245 μ long and 40 μ diameter, expanded at the apex. The perithecia arise from an erumpent parenchymatous stroma, sometimes singly, but more usually in small groups. In cultures on sterilised Vanilla stem, the base of the perithecium may be embedded in the stroma, or the perithecium may be simply seated on the stroma. In cultures on maize-meal agar, the perithecia (Plate III, fig. 3) are more deeply embedded in the stroma, so that they appear rather as loculi in a common stroma, with conoid ostiola. The wall of the perithecium is thick and parenchymatous. The perithecia are black, opaque, paler at the apex, rather strongly tomentose in some cultures, but only slightly so on Vanilla stems. The asci (Plate IV, fig. 3) are clavate, eight-spored, spores biseriate, 117–140 × 12–17 μ, the sporiferous part usually about 105 μ long. Long slender paraphyses are present. The ascospores are hyaline, continuous, allantoid, 25–35 × 8–11 μ. In culture the perithecial wall sometimes develops a cluster of setae. Parenchymatous bodies, resembling perithecia (Plate I, fig. 4), are produced in the agar.

The acervuli are subepidermal, becoming erumpent, circular, 230–280 μ diameter, or oval, 210 × 245 μ. The mass of spores is white or pallid, becoming pale pink and finally rose-purple. The conidia (Plate II, fig. 2) are greenish hyaline, cylindric, straight or slightly curved, 22–35 × 7–11 μ. The conidiophores (Plate IV, fig. 1) are septate, branched below, the branches terminating either in setae or in 1–2–septate basidia, 35–70 × 6–8 μ, at first hyaline, becoming brown. The setae are dark brown, straight, septate, subacute, slightly bulbous at the base, 105–235 μ high, 3–5 μ diameter below. The acervuli may appear black at first, or on dried specimens, because of the setae.

On maize-meal agar, the fungus forms a thin mycelial growth within the medium and the surface becomes dotted with greenish black bodies within five days. Some of these bodies are acervuli, others stromata. In a week, the surface is entirely greenish black. In about

a month, perithecia are produced in groups on the stromata. The agar is not coloured. Cultures from ascospores or conidia produce both stages in abundance. Cultures carried on by transfer of mycelium become sterile, though perithecia are produced up to the fifth generation.

There is little doubt that this species is *Gnomoniopsis Vanillae* Stoneman, though the latter was described as lacking a stroma, and having asci, 75–80 μ long ; its conidial stage was said to be a *Colletotrichum*, with crowded, septate basidia, 30–45 μ long. The dimensions of the conidia of the *Colletotrichum* are not given in Saccardo

It would also appear probable that this species provided Massee's *Calospora Vanillae*. The latter was said to be globose, with a prominent conico-cylindric curved ostiolum. The perithecia were immersed, with the ostiolum projecting, but Delacroix stated that the perithecia observed by him were not so deeply immersed as figured by Massee. The fungus had long, linear paraphyses, and its ascospores were subcylindric with rounded ends, slightly curved. But Massee described the spores a striseptate, and 15–16 × 5 μ, both of which details are at variance with the Ceylon species. Unfortunately, there does not appear to be any type specimen of *Calospora Vanillae* in existence. Miss Wakefield informs us that there is no type in Herb. Kew, and, from enquiries she has kindly made, it appears that there is none at the New York Botanic Garden. Consequently it is not possible to verify Massee's description.

The conidial stage would appear to be undoubtedly *Vermicularia Vanillae* Delacr. Delacroix withdrew his species as identical with *Gloeosporium Vanillae* Cke., but he described its spores as 27 × 11 μ, while Cooke's measurement of the spores of *Gloeosporium Vanillae* was 18–25 × 5–6 μ. As several fungi may occur together on diseased Vanilla, it is probable that the species examined by Delacroix on his revision of his fungus was not the same as that examined on the first occasion. Delacroix's figure strongly suggests the present species, but it is a *Volutella*, not a *Vermicularia*.

Species B.

The perithecial stage of this species is commonly obtained when specimens of Vanilla attacked by soft rot are kept in a glass dish, but it has not been observed in the field.

The perithecia are erumpent, becoming almost superficial, scattered or clustered, black, pale at the apex, subconoid, up to 200 μ diameter and 175 μ high. The wall is parenchymatous. The asci (Plate IV, fig. 6) are lanceolate or clavate, with obliquely biseriate spores, 54 × 12 μ, without paraphyses. The ascospores are fusoid or subcymbi-

form, curved, continuous, hyaline, ends subacute, 14–20 × 5–6 μ. In culture on maize-meal, some of the perithecia have a pale conical beak up to 70 μ high ; one perithecium, the body of which was 120 μ high and 85 μ diameter had a cylindrical beak 105 μ high and 40 μ diameter. The majority of the perithecia, however, are more or less conoid. A few hyphae may arise from the wall of the perithecium in culture.

The acervuli are circular or oval, up to 0·4 × 0·2 mm., dull pink or salmon pink. The basidia are hyaline, continuous, 25–50 × 3–4 μ. The conidia (Plate IV, fig. 9) are hyaline, continuous, cylindric, rounded at both ends or pointed at one end, 12–20 × 3–6 μ, the average of one hundred being 15 × 5 μ. Some acervuli lack setae, others contain olive brown, septate, obtuse, somewhat irregular setae, 55–105 × 4–5 μ, usually comparatively few in number. On the fresh diseased leaves, the epidermis overlying an acervulus may split and open widely, exposing the mass of spores, or the spores may be extruded in a tendril through a small aperture.

In cultures from ascospores on maize-meal agar the fungus develops a white, loose, superficial mycelium. On this mycelium minute black masses are produced which may develop into either acervuli or perithecia. In old cultures, perithecia may occur in continuous groups (Plate III, fig. 5) for a length of an inch. The agar is not coloured. Both perithecia and acervuli are produced abundantly in repeated subcultures on maize-meal agar, whether by transfer of ascospores, conidia, or mycelium. Setae were not found in cultures on maize-meal agar, and they occurred only rarely in cultures on sterilised Vanilla leaves.

The perithecial stage of this species is evidently *Physalospora Vanillae* Zimm. Zimmermann described the perithecia of his species as immersed at first, then erumpent, with a stout conical ostiolum, paler than the remainder of the perithecium, and with ascospores, tereto-fusoid, curved, somewhat obtuse, 24–28 × 5–6 μ. The latter measurement is greater than in Ceylon specimens. Shear and Wood refer *Physalospora Vanillae* Zimm. to *Glomerella cingulata*, but it is doubtful whether they had this species.

This appears to be the commonest species on Vanilla attacked by soft rot in Ceylon. Hence it would be expected that its conidial stage would be the one most frequently described by those who have examined similarly diseased specimens of Vanilla from other countries. But there is considerable doubt on this point, and it is preferable to postpone the discussion of these conidial forms until other species have been enumerated.

Species C.

This was first observed on definite spots on Vanilla leaves. The spots were large, oval, up to 7 cm. long and 2 cm. broad, greyish brown with a dark brown margin, the grey-brown part splitting out. The acervuli were situated chiefly near the margin of the spot or patch, and were black, oval, up to 0·5 × 0·25 mm., or circular, 0·25 mm. diameter, covered by the epidermis. The conidia were oblong-oval or elliptical, 12–16 × 4–6 μ, on short basidia. Branching hyphae with terminal conidia occurred in old acervuli. Setae were not found.

Subsequently this species was found on leaves and stems attacked by soft rot, *i.e.* without definite spots, and was taken into culture.

In cultures on maize-meal agar, a thin, hyaline layer of mycelium developed over the surface, on which, within a week, there appeared small black stromata which produced pink masses of spores. These stromata usually occurred in zones. When old, the conidia in the acervuli germinated and formed flattened pulvinate loose masses of hyphae. Setae occurred rarely. The agar was not coloured. On sterilised Vanilla leaves the growth was similar, but no setae were found. Perithecia were not formed in culture, but globose parenchymatous bodies, with a thick brown cortex, and hyaline and partly hollow within, occurred in the medium in maize-meal agar cultures.

The spores, in culture, were hyaline, continuous, usually oblong-oval but sometimes cylindric, 12–18 × 5–6 μ. (Plate IV, figs. 10–12). The basidia were hyaline, septate, irregularly constricted, 15–25 × 5–6 μ. The basal layer of the acervulus, in culture, is more compact and darker in colour (olive brown) than in the acervuli of species B or D. The setae are black, acute, 80–105 × 2–3 μ; they occur rarely and late. Dark, olive brown hyphae grow out from the base of the acervulus.

This species differs from the *Gloeosporium-Colletotrichum* stage of species B in its irregular septate basidia, and in the shape of its spores.

Species D.

This species occurs on brown sodden leaves and stems, and is usually the commonest form on old diseased leaves which have withered and dried. The acervuli are pink, 140–175 μ long and 95–105 μ broad, the basal stroma being pale olive brown,. The basidia are hyaline, not septate, regular, rounded or acute above, 20–45 × 2–3 μ, sometimes 5 μ diameter. The conidia are ovate, or narrow-oval, rounded at one end and subacute at the other, hyaline, continuous, 12–25 × 3–7 μ. (Plate IV, figs. 13, 14) The setae are olive brown, sub-hyaline above, two to four septate, sometimes flexuose, 70–135 × 4–5 μ.

In cultures on maize-meal agar, a thin, superficial filmdeveloped, which produced conidia in abundance on the hyphae. Subsequently a white floccose mycelium was produced. Black stromata occurred at the edge of the slant. After about eighteen days, pink masses of spores appeared in large numbers all over the surface of the medium, and in some cases on the black stromata. The pink pustules were found to be a *Gloeosporium* stage at first, but developed setae later. When old, the white floccose mycelium became dull grey. Parenchymatous bodies were formed in the agar, similar to those in cultures of species C. Perithecia were not produced.

The agar became reddish pink, then brownish orange, then purplish brown, and finally tawny olive (Ridgway).

This species differs from C in its basidia and spores, as well as in its regular production of setae. The basal stroma of the acervulus is not well defined in cultures.

SYSTEMATIC

There are thus four species which usually occur in Ceylon on Vanilla leaves and stems attacked by Soft Rot. One of these forms acervuli which are white or pallid at first and so are readily distinguished. The other three form pink acervuli on the fresh moist specimens. On old dried withered leaves, from which the spore masses have to a great extent disappeared, all the acervuli may appear black.

The four species are :—

A. A *Botryosphaeria*, with a *Volutella* imperfect stage, the conidiophores of the *Volutella* being branched, the basidia septate, and the conidia cylindric, straight or slightly curved 22–35 × 7–11 μ. The densely fasciculate base is a marked feature of this imperfect stage.

B. A *Glomerella*, with a *Gloeosporium-Colletotrichum* imperfect stage, which produces few setae ; the basidia of this imperfect stage are hyaline, continuous, 25–50 × 3–4 μ, and the conidia, cylindric, sometimes acute at one end, 12–20 × 3–6 μ.

C. A *Gloeosporium-Colletotrichum* which produces setae in culture only and then sparingly ; its basidia are irregular, septate, short, 15–25 × 5–6 μ, and the conidia *oblong-oval to cylindric*, 12–18 × 5–6 μ. It has a dark, compact, basal stroma in culture.

D. A *Gloeosporium-Colletotrichum* which produces setae regularly; its basidia are continuous, regular 20–45 × 2–5 μ, and its conidia *ovate, or narrow-oval*, 12–25 × 3–7 μ.

The morphological differences between B, C, and D, exclude the supposition that C and D are non-ascigerous strains of B.

A is *Gnomoniopsis Vanillae* Stonem. and perhaps the basis of *Calospora Vanillae* Mass. It may be known as *Botryosphaeria Vanillae* (Stoneman). Its *Volutella* stage is *Vermicularia Vanillae* Delacr., and will stand as *Volutella Vanillae* (Delacr.).

B is *Physalospora Vanillae* Zimm., and will stand as *Glomerella Vanillae* (Zimm.).

For C and D, and the imperfect stage of B, there are a number of possible names, but without an examination of the type specimens, one can only make suggestions. Even with the aid of the types, it is doubtful whether any definite conclusions can be reached, as all these imperfect stages may occur on the same specimen. For the same reason, it is probable that some of the descriptions relate to more than one species.

Trullula Vanillae P. Henn. was said to have densely fasciculate, oblong-fusoid or clavate, slightly fuscous basidia, 10–14 × 4 μ, and oblongo-cylindric or clavate conidia. The dimensions of the conidia were not stated, and consequently it is impossible to make any use of this description. It would seem possible that the measurements given for the basidia were intended for the conidia.

Colletotrichum Vanillae Scalia was described as having very black acervuli, almost resembling a *Vermicularia* at first, erumpent and subcolumnar, with fasciculate, cylindric, one-septate basidia, 24–34 × 6·5—7 μ; conidia oblongo-cylindric, frequently inequilateral and almost curved, 18–21 × 5·5—7 μ; setae sub-tuberculate at the base, sub-rigid or flexuose. This appears, from the description, to be nearest to the *Volutella* stage of species A; it differs in having its setae sometimes thickened at the septa, and the conidia smaller.

Gloeosporium Vanillae Cooke was said to have acervuli covered by the blackened epidermis, and conidia, 18–25 × 5–6 μ, elongato-ellipsoid, straight, with rounded ends. This would appear, from the description, to answer best to species C, which has notably black acervuli, (though the colour is not due to blackened epidermis), and oblong-oval to cylindric spores. But the spore measurements given by Cooke are larger than those found for that species in Ceylon. Cooke's spore measurements are nearer those of species D, but the shape of the spores of the latter is different, and it produces setae regularly in nature. If this identification is correct, *Gloeosporium Vanillae* Cke. is not related to *Glomerella Vanillae* (Zimm.).

Gloeosporium Bussei Henn., with oblong-cylindric conidia, 11–15 × 4·5—5·5 μ, generally curved, and basidia 30 μ long, 3–4 μ diam., appears, from the description, to be referable to the *Gloeosporium-Colletotrichum* stage of *Glomerella Vanillae* (Zimm.).

Shear and Wood did not obtain perithecia in their cultures of the fungus from Vanilla on maize-meal agar. Their account suggests that they were dealing with two species, but the absence of perithecia or perithecium-like bodies in culture would appear to exclude all the four species under discussion. They did not describe the basidia or the shape of the spores, and the details given are insufficient for comparison.

The material examined by Massee was sent from the Seychelles in layers of blotting paper, and, *fide* Massee, it reached him in good condition. It is probable, however, that, under those conditions, the acervuli on the drying specimens would not open widely, and that may account for Massee's description of the masses of conidia as extremely minute, or extruded in tendrils. His *Hainesia* would appear to be undoubtedly a *Gloeosporium*; its basidia were simple or branched, not septate, up to 25 × 3 μ, and the conidia, 9–10 × 3·5—4 μ. This spore measurement is too large for *Phyllosticta Vanillae*, but smaller than that of the Gloeosporiums found on Vanilla in Ceylon. There is, however, a possibility that this form may have developed in transit and have produced spores smaller than usual. His measurement of the acervulus, "only just visible to the naked eye, rarely reaching 5 mm. in diameter" is probably an error for 0·5 mm. The conidia were said to be elliptic-oblong; the figure shows them slightly more elliptic than the usual *Gloeosporium* spore, with the ratios of length to breadth 6 to 2 or 5 to 1·5.

Massee's *Cytospora*, from his figure, is certainly not a *Cytospora*. It would appear to be merely a cluster of acervuli of a *Gloeosporium* which have not opened widely. The spores were said to be elliptic-oblong, 14–16 × 6–7 μ; the figure shows the ratio of length to breadth, 7 to 2·5. Massee did not observe setae.

In describing the formation of the pycnidia of the *Cytospora* Massee referred to a stroma, but it is not clear whether he meant more than the tissue of the supposed pycnidium; his figure does not show a stroma. Similarly, he stated that *Calospora Vanillae* developed on the old stromata of the *Cytospora*, but his figure of that species does not show a common stroma. Parts of his description might be read as indicating that *Calospora Vanillae* developed on a parenchymatous stroma, but that interpretation is doubtful.

As far as any conclusion is possible, it would appear probable that Massee's *Hainesia* and *Cytospora* were both the same *Gloeosporium*, and the same as the Ceylon *Gloeosporium* species C. In that case, they would be referable to *Gloeosporium Vanillae* Cke. *Calospora Vanillae* would appear to be based on the Ceylon species A, but the spores of the latter are larger and not septate.

INFECTION EXPERIMENTS

Infection experiments were carried out, with conidia from sub-cultures of the single spore cultures, on detached leaves and pieces of stem in sterilised glass dishes and on living vines. The material in all cases was washed with corrosive sublimate solution (1 in 1000) and rinsed thoroughly afterwards with distilled water. In the case of living plants, a gas jar was inverted over the upper part of the plant, on which the inoculations were made, damp cotton wool being placed inside and the mouth plugged with cotton wool. Checks were kept in all cases.

In the case of species A, 12 inoculations on detached leaves, 6 of which were on wounded areas, proved failures; the conidia germinated on the wounded areas and produced appressoria but nothing further ensued. Three inoculations on pieces of stem, after wounding, were successful, both conidia and perithecia being produced. On living plants, 8 inoculations in the axil of the leaf, 5 unwounded and 3 wounded, were unsuccessful; and 6 inoculations on wounded leaves were unsuccessful with one possible exception. In the last case, the leaf was gathered and placed in a glass dish, where it developed the conidial stage only.

Four wounded detached leaves inoculated with conidia of species B did not develop any disease, but 2 wounded stem cuttings similarly inoculated both produced acervuli and perithecia. Inoculations on living plants with this species were unsuccessful. These included 6 wounded and 12 unwounded in the leaf axil, 2 on the wounded stem, and 9 on wounded and 19 on unwounded leaves.

In the case of species C, no infection was obtained. Inoculations were made on detached leaves, 2 wounded and 2 unwounded; and on living plants, 6 on wounded and 4 on unwounded leaves.

With species D, 5 inoculations on unwounded detached leaves were unsuccessful, and only one succeeded out of 5 on wounded leaves. On 3 wounded stem cuttings, infection was obtained in each case. On living plants, 6 inoculations on leaves and 6 in the leaf axil, in each series 3 on wounded and 3 on unwounded areas, were unsuccessful; while of 15 inoculations on the leaf, 10 after wounding and 5 without wounding, only two of the latter were successful and that after several months. In this last instance, the plants were inoculated on December 15th, 1922, and the glass jars removed on December 23rd; the plants were then exposed to natural conditions, and the two leaves showed symptoms of the disease on March 18th, after four days heavy rain.

Omitting the doubtful instances in the case of species A and D, it is seen that of 29 inoculations with species A, only 3 were successful, namely those on wounded stem cuttings; with species B, only 2 of 54 inoculations were successful, these being again on wounded stem cuttings;

14 inoculations with species C were unsuccessful; of 40 inoculations with species D, 4 were successful, one on a wounded detached leaf and three on wounded stem cuttings.

It will be evident that the results of these experiments are too fragmentary to be of any use. No explanation can be offered of this failure to reproduce by inoculation a disease which is at times very virulent. In the present experiments the material was held in a saturated atmosphere in all cases, and the range of temperature included that of the period when the disease occurs naturally on Vanilla. This failure, however, is not extraordinary, with species of *Gloeosporium* and *Colletotrichum*.

It is noteworthy that in the case of the two leaf infections with species D on living plants, which are believed to be delayed infections, the disease made its appearance after four days' rain in the normally dry, hot weather. This is parallel to the behaviour of *Colletotrichum Camelliae* on tea, serious outbreaks of which frequently follow a few days of rain in the hot season.

The experiments unfortunately do not show which fungus is to be regarded as the cause of Soft Rot of Vanilla or whether any of the fungi under experiment exhibit a preference for the leaf or the stem. Of nine successful inoculations, eight were on pieces of stem.

OTHER FUNGI ON VANILLA

Hennings described *Phyllosticta Vanillae* from Java as "maculis effusis, pallidis; pycnidiis sublenticularibus, membranaceo-atris, pertusis, 50–60 μ; sporulis oblongis, subfusoideis, continuis, 4–5 × 1·5—2 μ, hyalinis." A *Phyllosticta* has been observed on *Vanilla* leaves in Ceylon, which is probably referable to this species. It occurred on dry diseased leaves in company with *Colletotrichum* species D.

Cavara, in 1895, described *Laestadia Traversi* on *Vanilla* leaves in Italy. The description, as given in Saccardo, is, "Peritheciis dense gregariis sub epidermide nidulantibus dein erumpentibus, patellaribus, ostiolo prominulo, cirro albo praedito; ascis cylindraceo-clavatis, 50 × 10-12 μ; sporidiis ellipticis hyalinis monostichis, 10 × 4 μ; paraphysibus nullis."

In Ceylon, a *Mycosphaerella* has been found on dry diseased leaves, in company with *Colletotrichum* species D. The perithecia are gregarious, on livid spots, black, slightly prominent, sub-epidermal, becoming erumpent, not beaked, 80 μ diameter. The asci are clavate, thick-walled, 32-36 × 7–8 μ. Paraphyses are absent. The ascospores are fusoid, hyaline, one-septate, not constricted, ends acute, 8–10 × 2–3 μ.

There would appear to be a possibility that this is identical with *Laestadia Traversi*.

A peculiar hyphomycete frequently occurs on Vanilla which has been killed by Soft Rot. In its fully developed form it consists of erumpent, cylindrical synnemata up to 0·3 mm. high and 0·2 mm. diameter, which expand at the apex into a fringed disc, 0·3 mm. diameter. The stalk is yellow, composed of parallel hyphae, and the disc whitish and convex. The marginal hairs of the disc are yellow-brown, septate, minutely spinulose, up to 100 μ long, 4–6 μ diameter, and terminate in an oval or clavate tip, 6–10 μ diameter. In many cases the stalk is wanting, and the disc is sessile or forms a slightly pulvinate sporodochium. The basidia are clustered at the apices of the conidiophores, and are fusoid, attenuated above, up to 18 μ long and 2 μ diameter. Each basidium terminates in a slender sterigma, which bears a single conidium. The conidia are hyaline, oblong-oval, one-septate, ends obtuse, 5–8 × 2 μ. This has been described (Ann. Perad., IX, p. 327) as *Actinostilbe Vanillae*, gen. et sp. nov. The hairs resemble the paraphyses figured by Delacroix for *Uromyces Joffrini*. Sydow (Mon. Ured.) states that there is no Uromyces on the specimen of the latter sent him by Delacroix. It may also be noted that Zimmermann described similar rough hairs as belonging to the *Colletotrichum* observed by him.

REFERENCES

Bernard, C. Un champignon parasite sur la vanille. Bull. Dept. de l'Agric. aux Indes Néerlandaises, XI. pp. 45-47, (1907).

Delacroix, G. Espèces nouvelles observées au Laboratoire de Pathologie Vegetale. Bull. Soc. Myc. France, IX. pp. 184-187, (1892).

Delacroix, G. Sur deux maladies du vanillier. Bull. Soc. Myc. France, XVIII. pp. 274-284, (1902).

Hennings, P. Die Pilzkrankheiten kultivierter Vanilla-Arten. Notizblatt d. Königl. bot. Gartens u. Museums, Bd. I, No. 3, pp. 87-89 (1895).

Hennings, P. Schädliche Pilze auf Kulturpflanzen aus Deutsch-Ostafrika. Notizblatt, etc., No. 30, pp. 239-243 (1903).

Massee, G. E. Vanilla disease. Kew Bulletin, 1892, pp. 111-120.

Maublanc, C. Maladies du Vanillier. L'Agriculture Pratique des Pays Chauds, 12e Ann. pp. 177-188; 277-287, (1912).

Meinecke, E. P. Les vanillieres des Tahiti et de Moorea. Papeete, 1916.

Shear, C. L., and Wood, A. K. Studies of fungus parasites belonging to the genus *Glomerella*. U. S. Dept. of Agriculture, Bureau of Plant Industry, Bull. 252, (1913).

Stoneman, B. A comparative study of the development of some anthracnoses. Bot. Gazette, XXVI. p. 110, (1898).

Zimmermann, A. Ueber einige Krankheiten und Parasiten des Vanilla. Centralb. f. Bakt., Abt. 2, VIII. pp. 469-481, (1902).

EXPLANATION OF PLATES

PLATE III, Fig. 1. Vertical section of a stroma of *Botryosphaeria Vanillae*, from culture on Vanilla stem, × 70.

Fig. 2. Ditto, a single perithecium, seated on a stroma, × 70.

Fig. 3. Vertical section of a stroma of *Botryosphaeria Vanillae*, from culture on maize-meal agar, × 40.

Fig. 4. Section of a perithecium-like body, produced in maize-meal agar culture of *Botryosphaeria Vanillae*, × 75.

Fig. 5. Section through a group of perithecia of *Glomerella Vanillae* from culture on maize-meal agar, × 40.

PLATE IV, Fig. 1. *Volutella Vanillae*, conidiophores and seta.

Fig. 2. Ditto, conidia.

Fig. 3. *Botryosphaeria*, ascus.

Fig. 4. *Volutella*, germinated conidium, with appressorium.

Fig. 5. *Botryosphaeria*, germinating ascospore.

Fig. 6. *Glomerella Vanillae*, ascus.

Fig. 7. Ditto, extruded ascospores.

Fig. 8. *Glomerella Vanillae*, *Gloeosporium* conidium.

Fig. 9. Germinated conidium, *Gloeosporium* stage of *Glomerella Vanillae*.

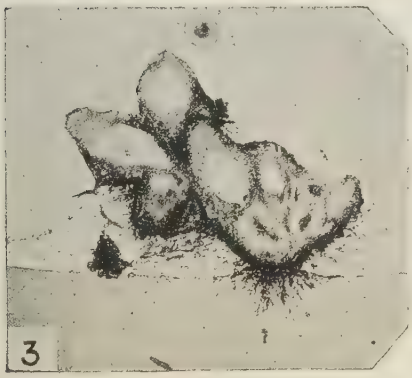
Fig. 10. Conidia of *Gloeosporium* species C (? *G. Vanillae* Cke.)

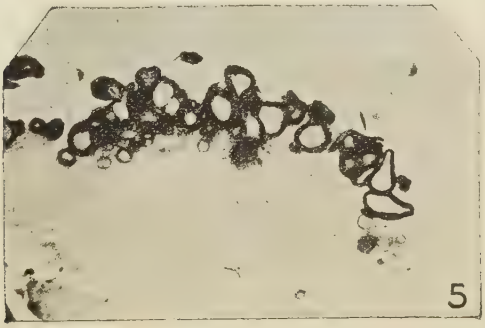
Figs. 11, 12. Ditto, germinated.

Fig. 13. Conidia of *Gloeosporium* species D.

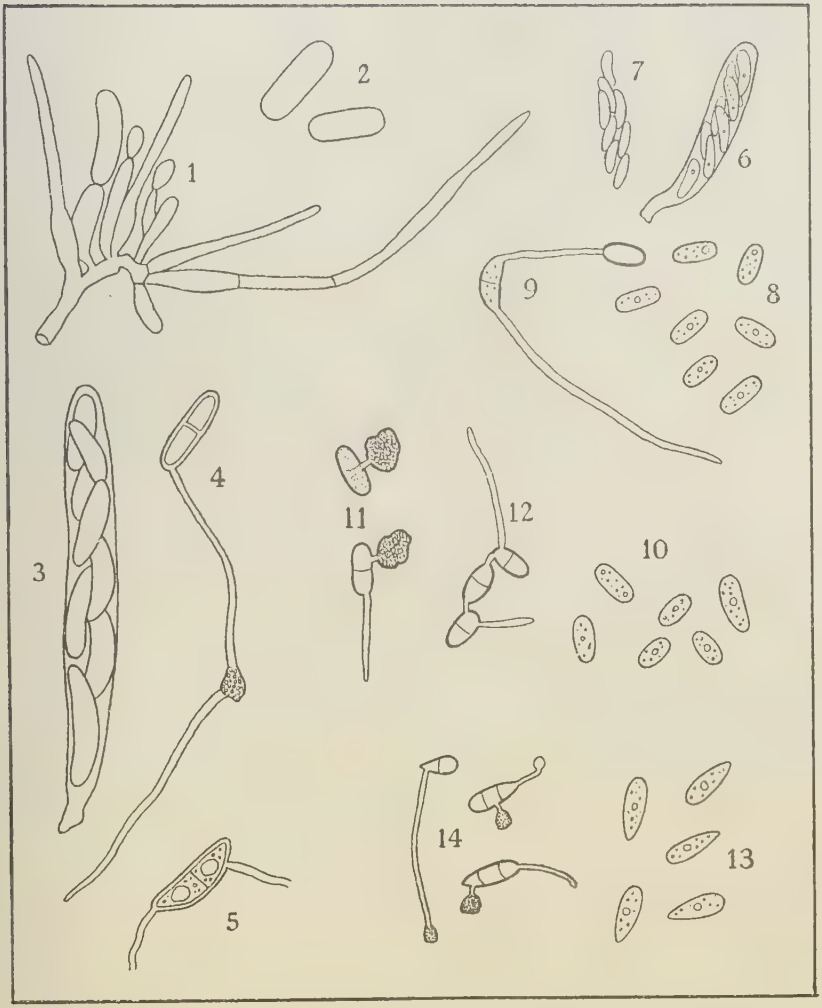
Fig. 14. Ditto, germinated.

[All figures on Plate IV, magnified 430 diameters.]





Vanilla Fungi



Vanilla Fungi

Grey Blight of Tea and Coconut—A Comparative Study

BY

L. S. Bertus

Assistant to the Mycologist and Botanist, Department of Agriculture, Ceylon

WITH SIX PLATES

The leaf diseases of tea and coconut which are known as Grey Blight are caused by species of *Pestalozzia*, but there has been considerable difference of opinion concerning the identity of these fungi. Consequently, the following comparative study of the Pestalozzias on the two plants has been undertaken.

Typical *Pestalozzia* spores on tea and coconut leaves (Plate VIII, figs. A, B.) are spindle-shaped or fusiform bodies, divided by four septa into a row of five cells, of which the three central are dark coloured, often pale brown, and the terminal cells hyaline. The apical hyaline cell is crested with hyaline cilia, or thread-like appendages, of varying length, which are probably of assistance in dissemination. Each spore has usually three cilia, but the number may vary from 2 to 4. To the lower hyaline cell is usually attached a pedicel or stalk on which the spore is borne. Abnormalities occur in the size of the spore and the number of coloured cells.

Work was chiefly concentrated on the size of the spores and the behaviour of the fungus when grown in culture. Pure cultures were obtained several times from diseased leaf spots by single spore isolations from poured plates. Spores from a single pustule were picked out with a pointed needle under a dissecting microscope, shaken in a little sterile water, and the material plated in Dextrose-meat extract agar. Spores from the same pustule were then carefully examined under the microscope to make sure that the pustule consisted of spores of the same variety as those plated. On the following day the spores had germinated in the medium. Those which were found isolated were picked out with a small piece of the culture medium and transferred to Maize-meal agar slants. Thus all the cultures were started from single

spores. Sub-cultures were made, as a rule, by transferring spores from tube to tube. Spores were grown in distilled water and standard nutrient solution in drop culture, a series of cultures being made in each case; on tea and coconut leaves, sterilized by boiling, in Roux tubes, and in various culture media: but for the purpose of comparison Oat agar, Maize-meal agar and French-bean agar were selected. In comparing the behaviour of the fungus that attacks tea with that of coconut the culture media were inoculated with each *Pestalozzia* on the same day, so that they were of the same age and grew under the same conditions.

Examinations of the fructification in the leaf and in culture were made by fixing the material in Chrom-acetic acid, embedding in paraffin, and microtoming. Gentian violet in 1% solution in water was used to stain the cilia in order to determine whether they were inflated at the tip (knobbed) or not.

The mean dimensions given in this paper were derived from measurements of fifty spores in each case. To ensure accuracy all measurements were made with the $\frac{1}{12}$th. inch objective and the drawings with the aid of a camera lucida.

GREY BLIGHT OF TEA

History.—Grey Blight of tea is one of the commonest leaf diseases of tea in Ceylon and appears to occur in all tea-growing countries. Massee, in Kew Bulletin 1898, p. 106, reported on Grey Blight of tea from material sent by Dr. Watt from Assam. He stated "An examination of the fungus sent from Assam on leaves of tea plant showed it to be identical with the parasite common on leaves of cultivated species of *Camellia* in Europe." He ascribed the disease to *Pestalozzia Guepini* Desmaz. This was the first scientific description published on Grey Blight of tea. It had been known in Assam many years before this, for in the same report Massee stated, "This disease under consideration is by no means new; specimens of tea leaves attacked by the *Pestalozzia*, now in the Kew Herbarium, are accompanied by the following note: 'Tea leaves (blighted), Cachar, 1872 growth, A. H. Blechynden.' A second lot of the leaves, suffering from the same disease, is accompanied by a note as follows: 'Leaves from a tea tree recovering from 'red spider,'.....T. B. Curtis. Received from Mr. Blechynden, Calcutta, by T.B.C., October, 1878.'

In 1899, Willis, then Director of the Royal Botanic Gardens, Ceylon, in a circular of the department on "Tea Blights" stated "This disease is due to the attack of a parasitic fungus known to science as *Pestalozzia Guepini*. It attacks tea in Assam, from which country it has very

probably been imported with tea seed." In 1907, Bernard in his paper "Sur quelques maladies de *Thea assamica*, de *Kickxia elastica* et de *Hevea brasiliensis*" ascribed Grey Blight in Java to *Pestalozzia palmarum* Cooke. In 1915 Sawada published his diagnosis of *P. Theae* as the cause of the Grey Blight of tea in Formosa. In 1916, in the Annual Report of the Government Botanist of the Uganda Protectorate Grey Blight of tea in that country is ascribed to P. *Guepini*. In 1918, Butler, in Fungi and Disease in Plants, p. 451, gave the cause of Grey Blight of tea in India as *P. Theae* Sawada. In a foot note he stated "Specimens on tea from India, Ceylon and Formosa were compared by the author at Kew, in 1914, with the type specimen of *P. palmarum*, and with Desmazières' specimens of *P. Guepini* from the type locality (Angers). The three fungi were found to be distinct. Subsequently (1915), Sawada published his diagnosis of *P. Theae* and specimens kindly communicated by him are identical with the Indian and Ceylon material."

The disease in nature.—The disease first appears on the upper surface of the leaves as minute yellowish spots which soon turn brown. These spots gradually increase in size, turn grey and often coalesce forming large irregular patches extending over the leaf. When the attack occurs near the margin of the leaf it generally spreads along the whole length of the margin. These patches are greyish in colour on the upper surface, and in some cases almost white, bounded by a ring dark-brown in colour. Outside this ring there is often a translucent band shading into the green healthy part of the leaf. The under surface of the diseased patch does not turn grey but is of a light-brown colour. The fructifications of the fungus appear as minute black dots on the grey patch on the upper surface of the leaf. They are usually scattered irregularly over the whole surface, but very often they are arranged in beautiful concentric zones chiefly at the edge of the patch. The fructifications also occur on the lower surface, but this is of rarer occurrence and when present comparatively few pustules are seen. When diseased leaves are plucked and placed in a moist chamber the spores are often exuded in the form of a black tendril. This appears to be chiefly due to the greater humidity under such conditions. Leaves taken from naturally-grown (*i.e.* unpruned) tea bushes under shade also showed this behaviour.

When a diseased patch is examined with a lens the epidermis of the leaf where the fructification occurs is seen raised and cracked, the crack being longitudinal, star-shaped or diamond-shaped. In microtome sections the spores are seen to be formed in pycnidia which are

bowl-shaped, lenticular, or elliptical, varying in width from 0·13 mm. to 0·33 mm., and isolated or more rarely aggregated. The pycnidia are sub-epidermal. Each pycnidium is completely closed by a pseudo-parenchymatous wall and has no ostiolum. It has a distinct basal wall, but thin and obscure upper and lateral walls. Spores are borne on pedicels or stalks 5–10 μ long and less than 1 μ diameter from a layer of cells in the basal wall. The pedicel is filiform, straight, or slightly curved, not separated from the spore by any cross wall, and is really a portion of the spore. When the spores are mature they are detached with the pedicel. The mass of spores forces up the epidermis and the thin pycnidial wall underlying it, and by finally rupturing both is liberated to the exterior. If sufficient moisture is present at this time they often ooze out in the form of a black tendril.

An examination of spores from diseased leaf spots gave the following results. The spore, including the terminal hyaline cells but not the pedicel or cilia, measured from 20 to 35 μ, with a mean of 25·6 μ; the coloured cells 15–22 μ, mean 18 μ; width 5–8 μ, mean 6·7 μ. The cilia or appendages were very long varying in length up to 40 μ, the maximum breadth at the base being about 1–1·5 μ; each terminated in a blunt knob. Each spore has usually 3 cilia, but the number varies from 2 to 4. The pedicel or stalk is persistent, straight or slightly curved to one side, and varies in length from 5–10 μ. One abnormal spore was seen having 5 coloured cells—the coloured cells measuring 25 × 6 μ and the whole spore, including the terminal hyaline cells, 33 × 6 μ. (Plate VIII, fig. A.) The hyphae penetrating the host were hyaline, septate, finely branched and generally difficult to trace, and 2 to 3 μ in width.

One peculiarity about this fungus is that its attack is usually confined to the old, hard leaves of the bush. The younger leaves are sometimes affected, but very rarely. The disease is prevalent mainly on neglected plantations, or when the bushes lack vigorous growth due to various causes as undrained sour soil, want of sufficient plant food, water-logging, or scarcity of water, or any cause that would render the bush weak.

CULTURES

Pure cultures of the *Pestalozzia* were got by placing leaves affected by the disease in a moist chamber for two days, when the spores were liberated from the pycnidia and appeared quite prominent as a small black mass on the surface. Very often they were extruded in a black tendril.

Spore germination. On germination the lowest of the three coloured cells usually produces a germ tube. This coloured cell is the germ-cell; before germination, it swells up, gradually loses its brown colour turning almost hyaline, becomes nearly spherical, marked very often by a light ring round the middle, and then puts out one, or sometimes two, germ tubes from the side. *In distilled water*, when the culture was four hours old, the lowest coloured cell in a large number of spores had swollen, and become spherical and almost hyaline preparatory to germination. Some spores had pushed out germ tubes from the sides, up to 20 μ long and nearly 3 μ wide at the base. In some spores that had germ tubes nearly 15 μ long, the germ-cell was seen to have undergone no change in colour or size, a distinct crack being present in the wall where the germ tube emerged. When a culture seventeen hours old was examined, the spores were found to possess, as a rule, one germ tube, non-septate or sparingly septate, emerging from the side of the usual germ-cell. Spores were also seen possessing two germ tubes arising from the same side of the germ-cell (Plate IX, fig. 2), or very rarely one on each side. In a culture twenty-four hours old the germ tubes were septate and branched. One spore had germinated in an unusual manner by pushing out a germ tube, which branched at the base, from the side of the uppermost coloured cell. A few spores had undergone no change whatever; in others the germ-cell was just beginning to lose colour and swell, while in others very short germ tubes were present. *In nutrient solution* spores had begun to germinate in about four hours. The mode of germination was similar to that in distilled water, but the growth was decidedly more luxuriant. In some spores the germ-cell had swollen to a width of 10 μ, and the germ tube was stouter than in water cultures and varied in width from 2·5 to 5 μ. It was also more branched, and more septate with distinct constrictions at the septa. As in water, in a culture twenty-four hours old a few spores had undergone no change, while some were preparing to germinate and others had very short germ tubes. The time normally taken for a *Pestalozzia* spore to germinate is therefore about four hours, but from the fact that some spores do not germinate within twenty-four hours in water or in nutrient solution it would appear that other factors, possibly age, may delay germination. When spores from single pustules from the leaf in nature or from culture media are taken for germination it does not necessarily follow that they are of the same age, although they originate from the same pustule.

Spores were grown in pure culture in Maize-meal agar, French-bean agar and Quaker oat agar. Details of growth on these media are given below.

Oat Agar. The slants were inoculated with spores from a Maize-meal culture. On the third day hyphae radiate from the point of inoculation for a distance of about 1 cm., and are confined to the surface of the medium. Aerial growth now begins, the mycelium appearing woolly and compact. The mycelium shows zoning but it is not very distinct owing to the rich growth of hyphae; the zones are approximately 2 mm. broad. The culture medium begins to change to an orange tint. In six to eight days the fungus overruns the whole surface of the medium with a rich aerial woolly mycelium and spreads over the glass in compact form. On the ninth day the mycelium as a whole presents a pinkish tinge and the medium itself a darker orange tint than it first possessed. On the twelfth day spores begin to be formed on the hyphae running along the inside of the glass above the culture medium. (Plate VIII, fig. E.) On the thirteenth day the mycelium is a loose, thick, heavy, pinkish felt lying on the medium, while the medium itself appears salmon-pink in colour. With age the pinkish colour of the mycelial felt and the salmon-pink colour of the medium gradually fade, and the hyphae which are growing on the glass, to such an extent as to almost fill the tube, appear as a continuous black mass owing to the innumerable spores borne on them. In some slants black bodies appear on the culture medium at about the same time as spores are formed on the hyphae in other tubes. Underneath some of these bodies a black longitudinal thread penetrates into the medium. These threads are masses of spores extruded in tendril form into the culture medium; they may be up to 4 mm. long.

Microscopic examination. Pieces of the culture medium containing these black bodies were microtomed. In microtome sections these bodies are found to be pycnidia and pseudo-parenchymatous stromata containing pycnidial cavities. In the culture medium a stroma composed of interwoven hyphae is present, 0·26 mm. to 0·52 mm. deep. Pycnidia are found in the felt of mycelium on the medium, or on the stroma (*i.e.* on the surface of the culture medium), or within the stroma in the medium, or in the medium itself. The pycnidia vary in size and shape. They are spherical, spherical and chambered, sub-globose, or oval, completely closed by a pseudo-parenchymatous wall which is never more than 40 μ thick. The spores are borne on the wall and are liberated by a rupture of the wall at any point. They may emerge into the air, or into the stroma in the culture medium, or into the culture medium itself. The following examples are cited in illustration of the variation in the shape of the pycnidium and the liberation of the spores:

(*a*) *Pycnidium formed in the stroma.* Spherical, 0·26 mm. diameter ; stroma slightly raised owing to the presence of the pycnidium ; pseudo-parenchymatous wall 20 to 40 μ thick ; spores liberated into the medium below by a rupture of the wall at the base, and filling an oval cavity 0·34 mm. long and 0·26 mm. wide in the medium (Plate V, fig. 6).

(*b*) *Pycnidium on the stroma.* Globose, 0·73 mm. wide and 0·52 mm. high, stroma slightly raised beneath the pycnidium so that the pycnidium appeared elevated on a cushion ; pseudo-parenchymatous wall 12 to 40 μ thick. Spores liberated by an aperture 0·13 mm. wide at the base into the culture medium where they filled an oval cavity 1 mm. long and 0·69 mm. wide. (Plate V, fig.1).

(*c*) *Pycnidium in the felt of mycelium on the medium.* Spherical, chambered, diameter about 0·78 mm.; wall 12 to 30 μ thick ; spores liberated into the air by a break in the wall at the top.

(*d*) *Pycnidium in the culture medium.* Spherical, chambered, diameter 0·22 mm. ; wall 10 to 40 μ thick ; spores liberated into the medium.

(*e*) *Pseudo-parenchymatous stroma.* Stromatic body somewhat globose. 0·91 mm. wide and 0·52 mm. high, present on the stroma formed in the medium, exhibiting in section 4 pycnidial cavities of various sizes ; one of these opened at the top and another at the side, liberating spores to the exterior ; the third opened at the base liberating spores into the culture medium, and the fourth opened into the stroma of the culture medium. (Plate V, fig. 3).

Spores. The length including the terminal hyaline cells was 22–36 μ, mean 27·4 μ; the coloured cells, 16–23 μ, mean 18·4 μ; width 6–8 μ, mean 6·9 μ; pedicel, 3 to 10 μ long and about 1 μ diameter; cilia, 2 to 4, generally three, up to 42 μ long, 1–2 μ diameter; apex of the cilia knobbed or not. Spores borne in pycnidia generally had the cilia knobbed, very rarely not knobbed, while those borne on free hyphae were generally not knobbed, though in many cases distinct swelling was visible at the apex. Spores with unknobbed cilia, when transferred to tea or coconut leaves, sterilised by boiling, in a Roux tube, readily formed knobs, while

those that already had knobs when grown on oat agar continued to produce cilia with knobs when transferred to tea or coconut leaves. The diameter of the hyphae was 2 to 3 μ. Free hyphae which bore spores were generally 3 μ diameter. Some hyphae were present, 4 μ diameter, constricted at the septa, frequently septate, much branched, and filled with fat globules. Lateral union of the hyphae is very common in culture. Stout hyphae may give rise to very fine branches. Submerged hyphae may be profusely branched and irregularly swollen, with swellings up to 6 μ diameter.

French-bean agar. The agar slants were inoculated with spores from a Maize-meal culture. On the fourth day the hyphae have grown for about 1 cm. from the point of inoculation, in a patch which is hardly perceptible and have then formed a band of aerial, woolly, compact hyphae, 1·5 cm. broad. This band extends from day to day until on the eighth day it reaches the end of the tube. The hyphae ascend the sides of the glass for about 4 mm. The mycelial growth as a whole is a white, smooth, felted layer with a heavy thick appearance lying on the medium. With age the medium changes to a brownish orange colour. On the eleventh day small greyish or blackish protuberances are seen in the white felted layer and underneath the felt too black bodies about the size of pin heads are seen scattered about. On the sixteenth day spores begin to be formed on the hyphae on the sides of the glass. In some tubes, instead of a continuous layer of aerial hyphae on the medium, successive bands of hyphae occur; the intervening spaces ultimately become filled up with aerial hyphae, forming a continuous felt.

Microscopic examination. The small blackish protuberances in the felted layer and the black bodies underneath it, when examined under a microscope are found to be pseudo-parenchymatous, composed of faintly yellowish cells. In microtome sections these bodies are found to be pycnidia and pseudo-parenchymatous stromata containing pycnidial cavities. A stroma composed of interwoven hyphae is present in the culture medium, varying in depth from 40–120 μ. Pycnidia are found on the stroma, or embedded in the stroma partly or completely, and a few in the felt of mycelium on the medium. The pycnidia are of various shapes and sizes, flask-shaped, globose, spherical and sometimes chambered, completely enclosed by a pseudo-parenchymatous wall which may be of uniform thickness or may vary in thickness in a single pycnidium. Spores are borne from a layer of cells on the wall and are liberated by a rupture of the wall at the base into the

culture medium, or at the top or sides to the exterior. Pseudo-parenchymatous stromata originate as small cushions on the stroma in the medium and are of various shapes. One or more pycnidial cavities may be present in each. The following are examples of the various forms of pycnidia, etc.

(*a*) *Pycnidium formed on the stroma.* Flask-shaped, height 160 μ greatest width 150 μ, no ostiolum, thickness of wall 20 μ, at the base 40 μ; spores borne on the sides of the wall but mainly at the base, and liberated by a rupture of the wall at the apex. (Plate V, fig. 4.)

(*b*) *Pycnidium partly embedded in the stroma.* (1) Globose, width 160 μ, height 120 μ, completely closed; wall between 10–20 μ thick, at the base 25 μ; spores borne from all sides of the wall and liberated to the exterior by a rupture of the wall at the top. (2) Globose 0·33 mm. wide and 0·26 mm. high; wall 20 μ thick; spores liberated by a rupture of the wall at the base into the culture medium and forming a tendril of spores 0·39 mm. long and 0·13 mm. wide.

(*c*) *Pycnidium completely embedded in the stroma.* Spherical, diameter 200 μ; wall 10 to 40 μ thick.

(*d*) *Pseudo-parenchymatous stroma.* Stromatic body almost globose in shape, 0·52 mm. wide and 0·39 mm. high; exhibiting in section four pycnidial cavities of different sizes; wall of cavities 20 to 40 μ thick.

Spores. The length including the terminal hyaline cells was 22–33 μ, mean 27·3 μ; coloured cells 16–20 μ, mean 18·2 μ; width 6–8 μ, mean 6·7 μ; pedicel 5–10 μ long and about 1 μ diameter; cilia 2–3 and up to 45 μ long. Spores with knobbed and unknobbed cilia were both present in the culture; the latter when grown on sterilised tea or coconut leaves readily produced knobs. The hyphae were hyaline, septate, branched and 2–3 μ diameter, those bearing spores being 3 μ diameter. Old hyphae were distinctly constricted at some of the septa. Some of the hyphae were 4 μ in diameter.

Maize-meal agar. The agar slants were inoculated with spores from a Maize-meal culture. On the third day hyphae have grown from the centre of inoculation for about a centimetre in an almost imperceptible patch on the medium and have then formed an aerial growth presenting the appearance of a white puff standing erect on the medium. On the following day the hyphae have spread from this puff for about another

centimetre along the surface of the medium and have then formed another puff of aerial hyphae. The formation of puffs at regular intervals takes place till the bottom of the test-tube is reached. As the culture advances in age the intervening spaces between some of the puffs are gradually filled up with hyphae so that the growth as a whole presents a woolly appearance. When the culture is twelve days old the interior hyphae of the woolly puffs appear greyish or blackish in colour owing to masses of spores which are formed on the loose hyphae. Hyphae also grow along the glass up the sides of the test-tube for about a centimetre in a compact form and bear spores in abundance. In some tubes black bodies, up to 4 mm. in diameter, consisting of a mass of spores, appear under the woolly growth.

Microscopic examination. In microtome sections the black bodies are found to be pycnidia with their extruded spores. No definite stroma is present in the culture medium, but a loose network of hyphae or pseudo-stroma, 0·26 mm. to 0·39 mm. deep, extends from the surface of the medium inwards. The pycnidia vary in size and shape, being spherical or oval, 0·2 to 0·78 mm. high and 0·2 to 0·46 mm. diameter, and either simple or chambered. (Plate V, figs. 2, 5). They are scattered or clustered, some being united, with a common wall at the point of union. They may be superficial, slightly embedded in the pseudo-stroma, or completely immersed in the latter. The pycnidia which were embedded in the pseudo-stroma were spherical and not chambered. The pycnidia are completely closed by a pseudo-parenchymatous wall which varies in thickness from 15 to 25 μ in different pycnidia. In some pycnidia the thickness of the wall is variable, while in others it is uniform. Spores are borne on the wall and are liberated by a rupture of the wall at the top or side. Spores which are liberated from pycnidia situated on the pseudo-stroma are unable to reach the surface owing to the presence of the woolly felt. (Plate V, fig. 2). In rare cases they broke through the felt and spread over the top of it.

Spores. The length including the terminal hyaline cells was 22–32μ, mean 26·6 μ; the coloured cells, 15–20 μ, mean 18·5 μ; width 6–8 μ, mean 6·8 μ; pedicel, 3–7 μ long and about 1 μ diameter; cilia, 2–3 up to 40 μ long and from 1 to 2 μ wide, apex knobbed or not knobbed. The spores borne in pycnidia had knobbed cilia, while those borne on the free hyphae had cilia not knobbed. Spores with unknobbed cilia when grown in Roux tubes on sterilised tea and coconut leaves readily formed knobs. The hyphae were hyaline, septate, branched, and 2–3 μ in diameter; those bearing spores were about 3 μ diameter. Some hyphae were up to 5 μ in diameter.

The following table gives the dimensions of spores in nature and on the various culture media :—

Media.	Range of length including terminal hyaline cells.	Mean length.	Range of length of coloured cells.	Mean length.	Range in width.	Mean width.
Tea leaves in nature.	20–35 μ	25·6 μ	15–22 μ	18·0 μ	5–8 μ	6·7 μ
French-bean agar.	22–33 μ	27·3 μ	16–20 μ	18·2 μ	6–8 μ	6·7 μ
Oat agar.	22–36 μ	27·4 μ	16–23 μ	18·4 μ	6–8 μ	6·9 μ
Maize-mealagar.	22–32 μ	26·6 μ	15–20 μ	18·5 μ	6–8 μ	6·8 μ

The chief feature on all the three media is the rich fluffy growth of aerial hyphae, which ultimately forms a thick, heavy, compact felt of white mycelium lying on the medium. No formation of tufts of hyphae occurs. In the French-bean agar and Oat agar a stroma is formed in the culture medium, but in the Maize-meal agar there is only a loose network or pseudo-stroma in the medium.

Spores were borne in pycnidia and in pseudo-parenchymatous stromata containing pycnidial cavities. In all the three media the pycnidia were mainly present on the stroma or pseudo-stroma, and very few in the felt on the medium. They were of various shapes and sizes, completely enclosed by a pseudo-parenchymatous wall and had no ostiolum, the spores being liberated by a rupture of the wall anywhere. In a large number of cases the spores were liberated into the stroma or culture medium by a rupture of the wall at the base, and formed a mass of mature spores in a cavity in the stroma or medium as the case may be. In addition to the production of spores in pycnidia, spores were also borne in large numbers on the free aerial hyphae.

In all the three media the spores possessed very long cilia of varying length, some in the French-bean culture attaining lengths of 45 μ. The cilia varied in number from two to four. The majority of the spores in culture had the cilia knobbed, but many were not knobbed. These spores with unknobbed cilia when transferred to tea or coconut leaves

sterilised by boiling in a Roux tube readily formed knobs. The length of the pedicel varied from 3 to 10 μ.

Spores were also grown in pure culture in Tea leaf-juice agar, though not for the purpose of comparative growth, but it is of interest to note that some spores in this culture medium germinated from the apical hyaline cell. Germ tubes were seen in various stages of growth, non-septate, or septate and branched, and varying in diameter from 2 to 2·5 μ. One spore had a non-septate germ tube 65 μ long and 2 μ diameter at the base with a small branch at one side. Another had a germ tube 70 μ long and 2 μ diameter and with only one septum. One abnormal spore produced in this medium had only 2 coloured cells, while another spore had 4 coloured cells, the whole spore measuring 37 × 6 μ. The cilia were very long and some attained 55 μ in length.

INOCULATIONS

(A) On tea.

(1) Four tea leaves were plucked, washed with distilled water, spores previously mixed with a few drops of standard nutrient solution placed on them and kept in a moist chamber. Twelve inoculations were made, 6 on the upper surface and 6 on the lower. On examination a fortnight later no trace of infection was evident. The control was free.

(2) Tea plants about 6 inches high, growing in a pot, were inoculated in the following manner. Spores from a Maize-meal culture were grown in standard nutrient solution in drop culture. After 24 hours a large number of spores were found to have germinated. The cover glass with the drop then was placed on the leaf and the plants were covered with a bell glass. 8 inoculations were made on the upper surface. When examined microscopically 18 days later there was no trace of penetration. The inoculated leaves were kept moist from the third day after inoculation by pouring cold sterilized water on them. The control was free.

(3) Four tea leaves were washed with distilled water, and wounded by shaving off a small area of the epidermis with a razor. They were then inoculated with mycelium and spores from a pure culture of Maize-meal and placed in a moist chamber. Six inoculations were made in all, three on the upper surface and three on the lower. When examined 11 days later, 4 inoculations were found to have taken. In two cases fructifications were present.

(4) Tea leaves were washed with distilled water, wounded by pricking with a sterilized needle and placed in a moist chamber, 9 wounds being made, 6 on the upper surface, and 3 on the lower. The wounds were then inoculated with mycelium and spores from a culture on

Maize-meal agar. Three days after inoculation the area round the wounds began to discolour. Examined microscopically 13 days after, all the inoculations were found successful except one. One leaf which was inoculated in two places took infection very well. On a leaf which had three inoculations, one wound which had an original area of 5 mm. by 5 mm. extended to 3 cms. by 2 cms.; a second wound from 4 mm. by 4 mm. extended to 10 mm. by 8 mm; while the third wound from 4 mm. by 3 mm. extended to 5 mm. by 4 mm. On one leaf inoculated in three places a rot set in from two wounds and extended along the edge practically covering three-quarters of the area of the leaf, but the third inoculation was unsuccessful. Spores were produced in abundance from pustules. On a leaf which had only one inoculation, the original area of 3 mm. by 3 mm. extended to 5 mm. by 4 mm. The control was free.

(5) Seven inoculations were made on the under surface of leaves of a tea bush in the open, both old and young leaves being selected for inoculation. Pieces of Maize-meal culture containing spores and mycelium were used, and moist cotton wool was placed over the inoculum, one or more leaves being enclosed in a large glass tube, of which the open end was plugged with cotton wool. Before inoculation the leaves were washed with sterilized water. Examined 15 days later, all the inoculations were found to have failed.

(6) In the following experiment hyphae only from a luxuriant growth from a Maize-meal culture were used. The leaves were first washed with 0·1 per cent corrosive sublimate and then with distilled water. (1) Three inoculations were made on the upper surface, a piece of the culture medium containing the hyphae being placed on the leaf, a pad of moist sterile cotton wool over it, and then a piece of wax cloth, the whole being secured to the leaf by a slide-on clip. (2) Three inoculations were made on the under surface in a similar manner. (3) Three inoculations were made on petioles of half grown leaves and three on petioles of mature leaves, but in this case only moist cotton wool was used without the wax cloth. All the inoculations were made on a bush in the open, and the whole bush was covered with a cage of jute hessian to keep off sunlight. From the 4th day after inoculation the cotton wool was kept moist by wetting with sterilized water. When carefully examined 24 days later, all the inoculations were found to have been unsuccessful. The leaves chosen for experiment included both mature and half mature ones.

(7) The leaves of plants about 6 inches high were washed with sterilized water and inoculated on the under surface with a Maize-meal agar culture. Over each piece of the culture was placed a piece of cotton wool moistened with distilled water. Young and old leaves were selected

for inoculation. Nine inoculations were made in all. The plants were in a pot and covered with a bell glass. When examined 24 days later there was no trace of any infection.

(8) Full-grown tea leaves on a bush in the open were washed in 0·1 per cent corrosive sublimate and then in distilled water and inoculated on the under surface from a Maize-meal agar culture. The culture was growing vigorously and it possessed a good crop of spores. Spores and mycelium, with a small piece of the medium were used for inoculation. Five inoculations were made. The branch bearing the inoculated leaves was enclosed in a gas cylinder and the open end plugged with cotton wool. When the inoculations were examined 20 days later, no infection could be observed.

68 inoculations were made in all,—17 on the unwounded upper surface of the leaf, 30 on the unwounded lower surface, 15 on the leaf after wounding, and 6 on the petioles. The inoculations on the uninjured upper and lower surfaces of the leaf were all unsuccessful, while out of the 15 inoculations on the wounds 12 were successful; those on the petioles were all failures.

(B) On coconut.

(1) Coconut seedlings about $2\frac{1}{2}$ ft. high were selected for this experiment. Prior to inoculation the leaves were washed in 0·1 per cent corrosive sublimate and then in distilled water. Inoculations were made on the under surface of the leaves, 14 on the uninjured leaf and 6 after wounding—the wounds being caused by gently scraping the epidermis with a needle lengthwise and crosswise so as to cover an area of about 4 mm.×4 mm. The inocula used were small pieces of Maize-meal agar culture containing hyphae and spores. The inoculated leaves were enclosed in large gas cylinders supported on tripods and the open ends plugged with cotton wool. Three days later signs were evident of the wounded inoculations taking in all cases. The original wounded patch turned greyish on the upper surface, with a translucent band outside it shading into the green. The grey patch then became bounded by a reddish-brown margin about 0·8 mm. wide, while in the translucent band fine light-brown rings could be seen when examined carefully. 13 days after inoculation the diseased area showed a central grey patch surrounded by a reddish-brown zone about 0·8 mm. wide, then a translucent band about 1·8 mm. wide possessing two lighter brown concentric rings, and outermost, another reddish-brown zone slightly narrower than the one surrounding the grey patch. Here the fungus appeared to stop its growth and it did not proceed further during the four weeks it was kept under observation. All the 6 inoculations behaved practically in a similar manner, except two, which did not

show any concentric rings in the translucent band. Though the inoculations were successful the progress of the disease was very slow and limited. The unwounded inoculations were all failures. The control was free.

(2) Old and hard leaflets were chosen for inoculation. They were cut into lengths of about 5 inches, washed in sterile water and placed in a moist chamber. The undersurface was inoculated with pieces of the culture medium bearing abundant masses of spores from a fresh culture. Ten inoculations were made, but all were found to have failed when examined 22 days afterwards. The control was free.

In all, 30 inoculations were made on the lower surface of the leaf, 24 on the uninjured leaf and 6 after wounding. Only the latter were successful.

GREY BLIGHT OF COCONUT

History. Grey Blight is the common leaf disease of coconuts in Ceylon and appears to be equally common wherever coconuts are cultivated. Plant pathologists are generally agreed that the fungus responsible for the damage is *Pestalozzia palmarum* Cooke. In 1889 Drieberg investigated a leaf disease on coconuts in Ceylon. This disease was most probably Grey Blight, though the fungus was not identified. In the same year Potter examined coconut leaves attacked by the same disease and found a fungus which he thought was a *Phragmidium*. It is possible that the latter fungus was *Pestalozzia*. In 1900 Raciborski reported the disease for Java. In 1901 Busck reported a leaf disease in Cuba and the fungus was identified by Woods and Mrs. Patterson. In 1905 Ch. Bernard found the fungus doing damage in Java. In 1906 Petch reported the disease in Ceylon and Stockdale in Trinidad. In 1908 Butler found the disease in Travancore. Barret in 1912 and Baker in 1914 recorded the disease for the Philippines. In 1917 Richards reported the disease in the F.M.S. A study of this fungus was made to ascertain its real identity by comparison with the type at Kew and to compare this species with that on tea.

The disease in nature. The disease first becomes noticeable by the appearance of small, translucent, yellowish spots, more or less regular in shape, scattered about the leaflets. The spots gradually increase in size, and may remain isolated, or may run into one another, forming irregular patches which are at first yellowish and finally greyish white, edged by a dark-brown line, outside which is a ring of pale-green or yellow tissue. The diseased patch very frequently extends longitudinally, eventually covering the greater portion of the surface of the leaflet. It is difficult to say on which side of the leaflet the discolouration first appears.

but the pale yellow, and later the greyish discoloured areas are equally evident on both surfaces; these areas are shrunken and thinner than the healthy portions. It was invariably seen on leaflets which bore diseased spot, that the tips of the leaflets had the disease in an advanced stage, indicating that these parts were first attacked and that the fungus spread from them to the other parts of the leaf. When a large number of diseased spots have made their appearance, the whole leaf assumes a yellowish appearance and gradually becomes greyish and withered. The diseased patches crack, fall off easily, and appear ragged, especially along the edges. The older leaflets are chiefly affected; the central shoot is little affected except in very bad cases.

On examination of a diseased patch with a lens minute protuberances can be seen scattered irregularly all over the upper surface. The epidermis of the leaf where these protuberances occur is raised and cracked in a longitudinal or triangular manner, and in the centre of the crack a gray or black body is seen which is a mass of spores.

Attempts were made to cause these spores to issue in tendril form by placing diseased leaves in a moist chamber, but no success was attained.

In microtome sections these protuberances are found to be pycnidia, which are globose or lenticular, simple, gregarious, or scattered, varying in diameter from 0·13 mm. to 0·42 mm., situated chiefly on the upper surface of the leaf, very rarely on the lower surface. The pycnidia are sub-epidermal. Each pycnidium is completely closed by a pseudo-parenchymatous wall and has no ostiolum. It has a distinct basal wall up to 20 μ thick, and thin, often obscure, upper, and lateral walls up to 10 μ thick. The spore is borne on a pedicel or stalk, 2 to 5 μ long and less than 1 μ diameter, from a layer of cells on the inner wall of the lower half of the pycnidium. When the spores are mature they are detached with the pedicel, and are liberated by a rupture of the upper wall of the pycnidium and the epidermis overlying it.

An examination of spores from diseased leaf spots in the field gave the following results:—The spore, including the terminal hyaline cells but not the pedicel or cilia, measured from 15–25 μ in length, with a mean of 20·2 μ; the three coloured cells 12–16 μ, mean 13·8 μ; width 5–7 μ, mean 5·7 μ. The cilia or appendages terminated in a knob and varied in number from 2 to 3, but spores with four cilia were occasionally present. The cilia were generally about 20 μ long, but few spores were seen with cilia as much as 40 μ long. The pedicel or stalk varied in length from 2 to 5 μ (Plate VIII, fig. B). One abnormal spore was seen having 5 coloured cells, and another with 4 coloured cells. The hyphae penetrating the host were about 2 μ diameter, hyaline, septate

and finely branched, running between the cells. In sections no hyphae could be traced beyond the brown line surrounding the diseased patch. It would appear that this line marks the limit of damage done to the leaf.

Young as well as old palms are susceptible to the disease, but bad cases of attack generally occur on young palms. The disease is widespread and often assumes a virulent form on weak and neglected trees. No case has yet been reported of a palm having been killed by this disease.

CULTURES

Pure cultures of the fungus were obtained by cutting diseased leaflets from the field into suitable sizes of about five inches in length, washing them in 0·1% Corrosive Sublimate solution and then in distilled water, and placing them in a moist chamber for about forty-eight hours to soften the affected patches and facilitate the removal of spores.

Spore germination. Spores were sown in distilled water and nutrient solution in drop culture for germination study. In both these media the lowest of the three coloured cells was the germ-cell, and produced one or two germ tubes.

In distilled water when the culture was two and a half hours old, few spores showed the germ-cell becoming colourless and spherical, and when four hours old germ tubes 12 to 50 μ long and 1·5 to 2·5 μ diameter were seen protruding from the sides. In a culture five hours old one spore had two germ tubes coming out close to each other on the same side of the germ-cell. In a culture twenty-four hours old the majority of the spores had germinated (Plate X, figs. 11, 12, 13), sending out generally one germ tube which often branched at the base, but occasionally two, one on each side of the germ-cell. The germ tubes were sparingly branched and sparingly septate. In some cultures a good number of spores had undergone no change, while others had the germ-cell spherical and swollen but had not germinated. The time taken, therefore, for a spore to germinate in water is usually about four hours, but the time of germination really depends on the individual spore. *In nutrient solution* early germination was more general and the growth of the pro-mycelium more luxuriant. After one hour in the culture medium the spores began to show signs of germination. The germ-cell loses its colour, and becomes spherical and swollen, increasing to about 8 to 9 μ in diameter. In a culture four hours old, the majority of the spores had germinated. The germ-cell of some spores had swollen to a diameter of nearly 10 μ, and had produced generally one germ tube, but sometimes two, one on each side of the germ-cell, non-septate, and varying in length from 3 to 15 μ and in diameter from 2 to 4 μ. In a

culture twenty-four hours old the germ tubes were of varying length, much branched and septate, varying in diameter up to 6 μ. (Plate X, figs. 7-10). Very often each spore possessed two germ tubes, one on each side of the germ-cell. The time taken, therefore, for a spore to germinate in nutrient solution is about four hours.

Spores were grown in pure culture in Maize-meal agar, French-bean agar, and Quaker oat agar. Details of growth on the media are given below:

Oat agar. The culture tubes were inoculated with spores from a Maize-meal culture. On the fourth day the hyphae have grown 3·5 cms. from the point of inoculation and show zoning, the rings of hyphae forming the denser parts of the zones, being a little less than 1 cm. apart. With progress in growth the hyphae unite into small masses to form white tufts; these tufts are scattered all over in abundance, but are chiefly present at the denser parts of the zones. On the seventh day the mycelial growth becomes pink while the medium turns salmon-pink. On the eighth day a black mass of spores begins to be extruded from the centre of each tuft, and on the tenth day the hyphae have overrun the whole surface of the medium which is studded all over with these small black masses. The salmon pink colour of the medium begins to fade when the culture is eleven days old and fades completely with age. When the culture is old the mycelial growth on the surface of the medium is hardly visible owing to the abundant formation of the small black pustules of spores. Hyphae grow up the sides of the tube for a distance of about 5 mm.

Microscopic examination. Single masses of spores, when picked out with a needle, come off very easily and appear to be situated superficially on the loose hyphae growing on the medium. When pressed under a cover glass and examined, the spores are seen to arise in a mass of pseudo-parenchymatous cells faintly yellowish in colour. In microtome sections these pseudo-parenchymatous bodies are found to be distinct pycnidia. Pycnidia are present in large numbers on the loose mycelium growing on the medium and are of diverse shapes and sizes, globose, rectangular, spherical, rectangular oval, laterally oval, etc. They occur singly, or in groups very often having common walls. The pycnidia are completely closed by a pseudo-parenchymatous wall, which may be of uniform thickness or may vary in thickness in a single pycnidium. Spores are borne on the wall and liberated by a rupture of the wall anywhere. A definite stroma composed of interwoven hyphae is found in the culture medium, varying in depth from 0·22 mm. to

0·26 mm. A few spherical pycnidia are embedded in this stroma partly or completely, (Plate VI, fig. 5), and their spores are liberated by a rupture of the wall at the top or sides to the exterior, or at the base into the stroma or culture medium. The following examples are cited:

(*a*) *Pycnidia in the loose mycelium on the culture medium.* (1) Spherical, diameter 85 μ; wall 18 μ thick. (2) Globose, width 70 μ, height 50 μ, wall 6–10 μ thick. (3) Rectangular oval, width 120 μ, height 70 μ, wall 5–15 μ thick. (4) Globose, width 240 μ, height 180 μ, wall 20 μ thick; spores liberated by a rupture of the wall at the top. (5) Laterally oval, width 130 μ, height 70 μ, wall 6 μ thick; spores liberated by a rupture of the wall at the side. (6) Spherical, diameter 100 μ, wall 8 μ thick.

(*b*) *Pycnidia in the stroma formed in the medium.* (1) Spherical, solitary, embedded in the stroma, surface of stroma slightly raised owing to presence of the pycnidium; internal diameter 140 μ; wall 20 μ thick; spores liberated to the exterior by a rupture of the wall at the side. (2) Spherical, and similar to the above but with a diameter of 160 μ; spores liberated by a rupture of the wall at the side into the stroma, into an almost spherical cavity about 100 μ diameter which is filled by the spores.

Spores. The length including the terminal hyaline cells was 15–23 μ, mean 18·8 μ; the coloured cells, 10–15 μ, mean 12 μ; width 5–7 μ, mean 5·5 μ; pedicel when present 1–5 μ in length, very often not present; cilia 1–2 in number, rarely three, short, and generally up to about 5 μ in length, rarely reaching 10–12 μ, apex of cilia not knobbed. Attempts were made to cause the cilia to knob by growing spores from culture on tea and coconut leaves sterilised by boiling in Roux tubes, but without success. The comparatively young hyphae were thin, sparingly branched and non-septate. At a later stage septa are formed and in old cultures they are very frequent. The hyphae were not generally constricted at the septa, though distinct constrictions were seen in some hyphae. The hyphae which appeared pink in mass were hyaline when mounted in water and examined under the microscope. The diameter of the hyphae was up to 3 μ. Some hyphae were profusely branched and irregularly swollen, the width at the swellings reaching nearly 7 μ. Some old hyphae were full of fat globules.

French-bean agar. The agar slants were inoculated with spores from a pure culture. On the fourth day the hyphae have grown a distance

of 2 cms. and have collected at irregular intervals into small white masses presenting the appearance of tufts. On the fifth day zoning is evident and the culture medium begins to assume a brownish-orange colour. On the sixth day the mycelial growth presents a faint pinkish tinge; tufts of white or pinkish hyphae are scattered all over and from the centre of each tuft a small black mass of spores is extruded. The intervening spaces between the tufts are covered with hyphae matted together to form a film of mycelium on the medium, sprinkled all over in abundance with these tufts of hyphae. By the eleventh day all the tufts have produced black masses of spores, and the film of mycelium is covered all over by countless numbers of these small black masses, the tufts themselves not now being visible. Very fine and scattered hyphae ascend the sides of the tube for a few millimetres.

Microscopic examination. Single masses of spores were picked out with a needle and examined. The spores are extruded from pycnidia. The pycnidia are spherical, flask-shaped, or globose, brownish-yellow in colour, thin-walled, completely closed and lacking an ostiolum, single or aggregated, slightly embedded in the culture medium, or borne on the film of mycelium on the medium. The diameter of the pycnidia varies from 100 to 250 μ. The spores are liberated by a rupture of the neck in the flask-shaped pycnidia or by a rupture at the top in the others. In one instance, when a single flask-shaped pycnidium was being examined, spores were seen being liberated in quick succession through a vertical split at the apex. Many spores had the lowest coloured cell swollen and light in colour, indicating that the preliminary stages of germination had begun inside the pycnidium. A comparison of the size of the pustule of spores extruded from a single pycnidium with the size of the pycnidium itself leads to the supposition that spores are formed in rapid succession within the pycnidium.

Further examination was made by embedding pieces of the culture medium and microtoming. In microtome sections all the black masses of spores are found to be liberated from pycnidia. A definite stroma composed of interwoven hyphae is formed in the culture medium. In some parts this stroma is 10–20 μ deep and in other parts 20–50 μ deep. Pycnidia are present in large numbers in the loose mycelium on the surface of the medium (Plate VI, fig. 1), and very few in the thin stroma in the culture medium. The shape of the pycnidia varies. They are spherical, globose, flask-shaped, oval, depressed globose with a conical apex, globose with a conical apex, rectangular oval. They are completely enclosed by a pseudo-parenchymatous wall which may be of uniform thickness or may vary in thickness in a single pycnidium. Spores

are borne from a layer of cells on the wall and are liberated by a rupture of the wall at any place. The pycnidia occur singly or in groups; two, one large and the other very small joined together by a common wall is of frequent occurrence (Plate VI, fig. 3); those which occur in groups may have either distinct walls or common walls. The following are examples of the pycnidia: (1) Spherical, diameter 60 μ, wall 10 μ thick. (2) Flask-shaped, greatest height 100 μ, greatest width 60 μ, wall 5 μ thick. (Plate VI, fig. 2). (3) Globose, diameter 80 μ, wall 4 μ thick. (4) Rectangular, width 160 μ, height 100 μ, wall 5–10 μ thick. (5) Laterally oval, width 160 μ, height 80 μ, wall 15 μ thick. (6) Globose, width 110 μ, height 80 μ, wall 10 μ thick. (7) Rectangular oval, width 240 μ, height 160 μ, wall 18–20 μ thick. (8) Laterally oval, width 0·26 mm. height 0·09 mm., wall 15 μ thick.

Spores. The length including the terminal hyaline cells was 15–22 μ, mean 18·7 μ; the coloured cells, 10–15 μ, mean 12 μ; width 5–6 μ, mean 5·4 μ; pedicel, generally absent, when present 1–3 μ long; cilia 1–2 in number, very rarely three, short and generally up to about 5 μ in length, rarely reaching a length of 10 μ; apex of cilia not knobbed; when spores were grown on sterilised tea and coconut leaves, the apex of the cilia underwent no change. The hyphae were hyaline, septate, branched, and had a general diameter up to about 3 μ. One abnormal spore with five coloured cells was seen in culture; the whole spore measured 25×6 μ; the coloured cells 20×6 μ; it had one cilium 5 μ long, and no pedicel.

Maize-meal agar. The agar slants were inoculated with spores from a pure culture. From the point of inoculation the hyphae run along the surface of the medium for about 1 cm. and stand out aerially more or less presenting the appearance of tufts. The fungus grows scantily and forms tufts again at a distance of about 1 cm. from the original tufts. A faint zoning is seen, but it is not well defined. The fungus then forms tufts irregularly all over the medium and as the culture becomes older a black speck arises in the centre of each of these white tufts, the black speck being a mass of spores. Spore formation begins on the seventh day, and by the tenth to twelfth day the whole surface of the medium is studded with these small black pustules of spores. At the edge of the tube where the culture meets the glass, a thin, scanty, growth of hyphae is seen to ascend the sides of the tube for a few millimetres. With advancing growth the medium acquires a cream colour.

Microscopic examination. In microtome sections the pustules of spores are seen to be liberated from pycnidia. The pycnidia occur in large numbers on the loose mycelium growing on the medium. No

definite stroma is formed in the medium but instead there is a loose network of hyphae, 0·52 to 0·65 mm. deep, the network gradually becoming scanty deeper in the medium. A few pycnidia are embedded in this network or pseudo-stroma, either partly or completely, and very few embedded in the culture medium itself. The pycnidia found in the loose mycelium on the surface are of various shapes and sizes; they are spherical, laterally oval, flask-shaped, cone-shaped, globose, sphaeroidal, rectangular, square with rounded corners, etc., and occur singly or in groups. A large pycnidium joined to a very small one, with a common wall, is of frequent occurrence; and sometimes two spherical pycnidia of practically the same dimensions are united laterally by a common wall. The pycnidia which are embedded in the pseudo-stroma are sphaeroidal in shape, while those embedded in the culture medium are oval. In every case the pycnidium is enclosed by a pseudo-parenchymatous wall, which may be of uniform thickness or may vary in thickness in the same pycnidium. Spores are borne from the sides of the wall and liberated by a rupture of the wall at any point. The pycnidia embedded in the culture medium liberate spores into a cavity in the culture medium itself. The following are examples of the pycnidia:

(*a*) *Pycnidia in the loose mycelium on the medium.* (1) Spherical, diameter, 110 μ, wall 10 μ thick. (2) Flask-shaped, height 180 μ, width 130 μ, wall 10 μ thick. (3) Laterally oval, width 0·26 mm., height 0·15 mm., wall 15 to 20 μ thick. (4) Cone-shaped, height 100 μ, width 85 μ, wall 8 μ thick. (5) Globose, width 55 μ, height 45 μ, wall 2–3 μ thick.

(*b*) *Pycnidium in the pseudo-stroma.* Sphaeroidal, partly embedded, diameter 160 μ, wall 18 μ thick.

(*c*) *Pycnidium embedded in the culture medium.* Oval, width 120 μ, height 60 μ, wall 15–20 μ thick, spores liberated by a rupture of the wall and filling a cavity in the medium at the side of the pycnidium.

Spores. The length including the terminal hyaline cells was 15–23 μ, mean 18·5 μ; the coloured cells, 10–15 μ, mean 12 μ; width 5–7 μ, mean 5·7 μ; pedicel not present in a large number of spores, when present 1–3 μ long; cilia 1–2 in number, very rarely three, short, generally up to about 5 μ long, rarely reaching 10 or 12 μ; apex of cilia not knobbed. The hyphae were hyaline, septate, branched, usually between 2–3 μ in diameter. Some hyphae were irregularly swollen and reached a diameter of about 5 μ at the swellings. Old hyphae are distinctly constricted at the septa, particularly when a branch arises near the septum.

Below is a table giving the dimensions of the spores in nature and on the various culture media:—

Media.	Range of length including terminal hyaline cells.	Mean length.	Range of length of coloured cells.	Mean length.	Range in width.	Mean width.
Leaves in nature.	15–25 μ	20·2 μ	12–16 μ	13·8 μ	5–7 μ	5·7 μ
French-bean agar.	15–22 μ	18·7 μ	10–15 μ	12·0 μ	5–6 μ	5·4 μ
Oat agar.	15–23 μ	18·8 μ	10–15 μ	12·0 μ	5–7 μ	5·5 μ
Maize-meal agar.	15–23 μ	18·5 μ	10–15 μ	12·0 μ	5–7 μ	5·7 μ

The chief feature of growth in all these three media is the accumulation of hyphae to form tufts. These tufts are originally white in colour and later assume a pinkish tinge. As the fungus advances in age, black pustules of spores are seen to arise from the centre of each of these tufts. In old cultures, the white mycelial growth on the medium was covered with these little black pustules in abundance. In the French-bean and Oat media a stroma is formed in the culture medium, while in the Maize-meal instead of a stroma a loose net-work of hyphae or a pseudo-stroma is present.

In all the three media, spores that appear to be in pustules are found to originate in distinct pycnidia. Pycnidia are present in large numbers on the loose mycelium growing on the medium and are of diverse shapes and sizes. They are spherical, laterally oval, flask-shaped, rectangular, sphaeroidal, globose, oval, rectangular-oval, cone-shaped, etc. They consist of a pseudo-parenchymatous wall, yellowish in colour, not possessing an ostiolum, and occur singly, or in groups very often having common walls. Spores are liberated by a rupture of the wall at any point. A few spherical or sphaeroidal pycnidia are embedded, partly or completely in the stroma formed in the French-bean and Oat agar, and in the pseudo-stroma in the Maize-meal agar. Spores were seen liberated from these by a rupture of the wall to the exterior,

or into the stroma or culture medium. In the Maize-meal agar, a few pycnidia are embedded in the culture medium, liberating spores by a break in the wall into the culture medium.

In all the media the cilia are very short, vary in number from 1 to 3 and are not knobbed. They are usually between 2 to 5 μ in length, rarely reaching 10 to 12 μ. In some spores the pedicel is not present; when present it is generally between 1 and 3 μ long, rarely attaining 4 to 5 μ in length. Attempts were made to cause the cilia to knob by growing the fungus on tea and coconut leaves, sterilized by boiling, in Roux tubes, but no success was attained. A peculiarity about this *Pestalozzia* is that the cilia are shorter in culture than in nature, and than although the cilia are knobbed in nature they are never knobbed in culture.

The base of a coconut petiole suspected to be attacked by *Phytophthora* was incubated, and pustules of *Pestalozzia* spores were hatched out corresponding in dimensions with the spores in culture, all possessing short cilia and not knobbed. The spores behaved in the various culture media in the same manner as those obtained from the leaf.

INOCULATIONS

(A) On coconut.

(1) Coconut leaflets were cut into lengths of about 5 inches, washed in 0·1 per cent corrosive sublimate, then in distilled water and placed in a moist chamber. The inocula used were small pieces of Maize-meal agar culture. 9 inoculations were made on the upper surface of the leaf, 9 inoculations on the lower surface and 9 by wounding the leaf with pin pricks. The 18 inoculations made without wounding were failures. The 9 wounded inoculations were all successful. Typical grey blight patches were formed and fructifications were noticed a month after inoculation. The control was free.

(2) 4 inoculations were made on the under surface of the leaf in the same manner as the above, but in this case the inoculum was enclosed in a circular ring of soft paraffin. Two inoculations were successful. Discolouration of the tissue began on the fourth day and the patch gradually increased in size. The other two inoculations failed to take. The control was free.

(3) Coconut seedlings about 3 ft. high were selected for this experiment. The leaves were first washed in 0·1 per cent corrosive sublimate and then in distilled water prior to inoculation. The inocula used were small pieces of Maize-meal agar culture. 4 inoculations were made on the lower surface of the leaf without wounding, and 5 inoculations by wounding, the wounds being caused by gently scraping

the epidermis of the under surface lengthwise and crosswise so as to occupy an area of about 4 mm.×5 mm. The inoculated leaves were enclosed in large gas cylinders supported on heavy tripods and the open end plugged with cotton wool. On the third day after inoculation signs were evident of infection on the wounded areas. The original wounded area formed a greyish patch on the upper surface with a translucent band outside it, shading into the green. With the further progress of the disease the spot presented the following appearance. Round the gray patch a reddish-brown margin about 0·5 mm. wide was formed and then a translucent band, about 1·5 mm. wide, bounded on the outside by another reddish-brown ring about 0·2 mm. wide. Outside this ring is another translucent band 0·5 mm. wide shading into the green. Black pustules of spores appeared on the gray patch 6 days after inoculation. All the wounded inoculations behaved practically in a similar manner. The unwounded inoculations failed to take. The control was free.

40 inoculations were made in all, 14 by wounding, 17 on the unwounded lower surface of the leaf, and 9 on the unwounded upper surface. All the wounded inoculations were successful. Of the 26 unwounded inoculations only 2 were successful.

(B) On tea.

(1) Full-grown leaves were washed in sterile water and inoculated with pieces of the culture medium bearing spores and hyphae. Prior to inoculation the leaves were wounded by shaving off a small area of the epidermis with a razor. 11 inoculations were made on the upper surface and 11 on the lower surface. The leaves were left in a moist chamber for 21 days, but none of the inoculations took effect. The control was free.

(2) Old and hard leaves on a bush in the open were washed in distilled water wounded by shaving off a small area of the epidermis of the upper surface of the leaf and inoculated with spores and hyphae from a pure culture. The leaves were enclosed in a large glass tube, the open end of which was plugged with cotton wool. 4 inoculations were made. 4 inoculations were made on the lower surface of full-grown leaves in a similar manner to the above, but without wounding; and 3 inoculations on the upper surface and 3 on the lower surface of tender leaves. All the 14 inoculations were unsuccessful. The control was free.

(3) Young tea plants about 7 inches high, were planted in a pot and covered with a bell glass. Leaves were washed in distilled water, wounded by pricking through and through with a sterilised needle, and the wounds inoculated on the top surface with pieces of Maize-meal agar culture. The culture was kept moist by frequent wetting with

distilled water. 6 inoculations were made, but although the inoculum remained on the surface for a fortnight no penetration took place. The control was free.

32 inoculations were made after wounding, 21 on the upper surface and 11 on the lower surface and 10 without wounding, 3 on the upper surface and 7 on the lower surface. All were unsuccessful.

COMPARISON OF THE TWO SPECIES

The spores of the species on tea are, on the average, larger than those of the species on coconut. The mean dimensions of the spores in nature and on the culture media employed are as follows:—

	Length including terminal hyaline cells.	Length of coloured part.	Breadth.
Tea sp. in nature.	25·6 μ	18·0 μ	6·7 μ
Tea sp. in culture.	27·0 μ	18·3 μ	6·8 μ
Coconut sp. in nature.	20·2 μ	13·8 μ	5·7 μ
Coconut sp. in culture.	18·6 μ	12·0 μ	5·5 μ

The species on tea, in culture, produces a rich fluffy growth of aerial hyphae which eventually form a compact, dense, white felt overlying the medium, whereas the species on coconut forms tufts of hyphae.

In the case of the tea *Pestalozzia* spores are borne in large numbers on the loose hyphae, but the coconut *Pestalozzia* does not produce any spores on free hyphae.

The tea *Pestalozzia* produced fewer pycnidia in culture than the coconut *Pestalozzia*, but the pustules of spores extruded from the pycnidia of the former were larger than those extruded from the pycnidia of the latter.

In the case of the tea *Pestalozzia*, pycnidia and pseudo-parenchymatous stromata were formed chiefly in the stroma in the culture medium, while in the coconut *Pestalozzia* cultures pycnidia were produced in abundance in the loose mycelium on the medium, and only very few in the stroma in the culture medium.

The cilia of the spores of the tea *Pestalozzia* are knobbed in nature. In culture, some spores have cilia which are not knobbed, but if these spores are sown on tea or coconut leaf sterilized by boiling in Roux tubes, they readily produce spores with knobbed cilia. The spores of the coconut *Pestalozzia* also have knobbed cilia in nature, but those produced in

culture had cilia without knobbed tips, and these did not revert to the knobbed form when sown on sterilized tea or coconut leaf.

The cilia of the tea *Pestalozzia* became very long in culture attaining lengths up to 45 μ, whereas the cilia of the coconut *Pestalozzia* remained comparatively short, up to about 12 μ.

These differences appear to be sufficient to maintain the two species distinct.

The species on tea with very minute differences agrees with that described by Sawada in Formosa in 1915. This Ceylon species is therefore *Pestalozzia Theae* Sawada.

Cooke described *P. palmarum* from a dead sprout of a germinating coconut from Bengal. An examination of the type showed that the dimensions of the spores are identical with those of the Ceylon species; Cooke's published description in Grevillea, Vol. IV, p. 114, does not agree with the actual spore dimensions of his specimen. There is no doubt that the Ceylon species on the coconut leaf is *Pestalozzia palmarum* Cke.

A VARIANT STRAIN ON TEA

When spores of *Pestalozzia Theae* were isolated and transferred to Maize-meal agar slants, the mycelial growth in one tube differed considerably from the rest in not being fluffy and not so luxuriant as the others. This tube was separated from the rest and kept under observation. On the ninth day spores began to be formed in pustules, and these, when examined microscopically, were found to differ considerably from *P. Theae* in the size of the spore, its width, the formation of the cilia, and the absence of a knob at their apices (Plate IX, figs. 2,4,5). Subcultures were taken from these. The chief characteristics of this spore are the peculiar swelling at the junction where the cilia originate, as shown on the drawings, and the branching of the cilia. The number of cilia varies from 3 to 6 on different substrata, and one, two, or even three may be branched.

A large number of diseased leaves attacked by grey blight from different localities were examined to ascertain whether this type of spore occurs in nature, but none was found. Single spores were again isolated from different patches and grown in culture, to find out whether this kind of spore would occur again in cultures; but this too was a failure, the spores in culture behaving normally. The variant spores were also grown on tea and coconut leaves sterilised by boiling in Roux tubes, and in both cases they underwent no change.

On sterilised coconut leaf the dimensions of the spores were 25–35 × 7–10 μ; the length of coloured cells was 16–22 μ; the cilia were up to 40 μ in length, and 2 to 6 in number; no pedicel was present. One abnormal spore with 5 coloured cells was seen, the whole spore measuring 36 × 9 μ and the coloured cells 29 × 9 μ; four cilia were present, up to 20 μ long (Plate IX, fig. 3.). On sterilised tea leaf the spores were, on the average, longer, varying in length from 28 to 42 μ and in width from 7 to 9 μ; the length of the coloured cells was 18–29 μ; no pedicel was present; the cilia were 3 to 6 in number and up to 30 μ long. As care had been taken to examine the pustule from which the spores were plated and isolated in order to make sure that the pustule bore spores of the normal kind, it would appear that this spore originated from a typical spore of *Pestalozzia Theae* and is a variant of that fungus.

CULTURES

Spore Germination. A series of hanging drop cultures were made in distilled water and standard nutrient solution. *In distilled water* the spores did not appear to thrive, the percentage of germinating spores being very low. In a culture five hours old the majority of the spores had undergone no change. Only a few had germinated, sending out germ tubes, 20 to 50 μ long and 3 to 3·5 μ diameter, from the lowest of the three coloured cells. One spore had germinated from the uppermost coloured cell. In a culture six hours old one spore had germinated from the second coloured cell and another from the uppermost coloured cell. In a culture twenty-six hours old, two spores had germinated from the apical hyaline cell. In a culture forty-eight hours old one spore which had only four cells had germinated from the side of the apical hyaline cell; another normal spore had formed a small spherical swelling on the top of the apical hyaline cell and from this two germ tubes had grown, one at the top and another at the side. The majority of spores did not germinate in water, although the culture was left for four days. It will thus be seen that water is unfavourable as a medium for spore germination in this case, and when germination does occur it is irregular. *In nutrient solution* germination was good (Plate IX, figs. 6, 7). In a culture two hours old the lowest of the three coloured cells in a large number of spores was losing its colour and becoming spherical. In a culture five hours old this spherical cell had swollen up to about 10 μ in diameter, and in a few spores small germ tubes had protruded from the sides. In a culture six hours old a large number of spores had germinated from this particular cell which had become colourless and had produced either one or two germ tubes, varying in length up to 70 μ and in diameter from 2·5 to 6 μ, much branched and

septate. Spores with three germ tubes from the same cell were occasionally present. In a culture twenty-four hours old some spores were just beginning to germinate. It will thus be seen that spore germination in nutrient solution takes place from the lowest of the three coloured cells, and the time taken for a spore to germinate is usually about five hours, though some may take as long as twenty-four hours.

Spores were grown in pure culture on Maize-meal agar, Oat-agar and French-bean agar. Details of growth on these media are given below.

Oat agar. The slants were inoculated with spores from a pure culture. On the third day hyphae radiate from the point of inoculation for a distance of about 1 cm. and are confined to the surface of the medium. The hyphae now run over the surface of the medium in an irregular fashion, the advancing hyphae showing a branching appearance. A slight zoning is evident, but hardly perceptible. On the fifth day hyphae collect here and there into small white masses, scattered all over the surface of the medium. On the sixth day the medium begins to assume a salmon-pink colour. On the seventh day the small white masses of hyphae turn greyish in colour and finally black, owing to the appearance of spores in the centre in pustule form. The growth is now slow, and with age the whole surface of the medium is studded irregularly with black pustules. Hyphae ascend the sides of the tube in thin irregular strands for about 3 mm. and form pustules of spores on the glass. On the thirteenth day the mycelial growth is pinkish in colour, and the medium salmon-pink chiefly at the edges. As the culture ages these colours vanish. No aerial growth of mycelium occurs at any time.

Microscopic examination. In microtome sections, a definite stroma is present in the medium to a depth of 0·26–0·52 mm. Pycnidia of various shapes and sizes, up to 1 mm. diameter, are situated on the stroma, or partly embedded in the stroma (Plate VII, figs. 5, 6, 7) completely closed by a pseudo-parenchymatous wall (Plate VII, fig. 4), which may vary in width in the same pycnidium. Spores are generally borne from all sides of the wall and liberated by a rupture of the wall anywhere. In one pycnidium the width of the wall varied from 20 to 80 μ, and spores were borne in this pycnidium from all sides of the wall except at the base. In another pycnidium, globose in shape, 0·29 mm. high, partly embedded in the stroma, spores were borne from all sides of the wall, the thickness of the wall varying from 20 to 30 μ. Some pycnidia liberate their spores into the stroma (Plate VII, fig. 5) or the culture medium. One was seen, globose in shape, 0·32 mm wide and 0·19 mm.

high, partly embedded in the stroma, which had liberated its spores at the base through an orifice 60 μ wide, opening into the stroma, where they occupied a cavity, oval in shape 0·22 mm. long and 0·16 mm. diameter. Many pycnidia were small and spherical, about 0·13 mm. in diameter; in these the spores were borne over the whole of the inner surface.

Spores. The length of the spore, including the terminal hyaline cells, was 25–35 μ, mean 29·2 μ; the coloured cells 17–23 μ, mean 19·4 μ; width 6–10 μ, mean 7·8 μ; pedicel not present; cilia 3 to 5 in number, and up to 30 μ long, generally three and branched. Abnormal spores having only one coloured cell or sometimes two coloured cells occasionally occur in culture. Many spores with unbranched cilia occur, but these possess the characteristic swelling at the point where the cilia originate. The cilia are not knobbed but rounded off at the apex.

The young hyphae are slender, sparingly branched and sparingly septate; in older stages the septa are common and when still older the septa are formed at frequent intervals. The larger hyphae, about 4 μ in diameter, are branched, constricted at the septa, and frequently filled with fat globules. Irregularly swollen hyphae are also present, up to about 6 μ diameter at the swellings. The hyphae which penetrate deeply into the culture medium are long, sparingly branched, closely septate and up to 3 μ in diameter.

French bean agar. French bean tubes were inoculated with spores from a pure culture. On the fourth day hyphae have grown 2 cms. and radiate in strands from the centre. From the fifth day onwards the advancing margin consists of hyphae radiating in strands. On the seventh day hyphae collect here and there into small white masses. From the eighth day onwards black pustules of spores are produced from the centre of each of these small masses, and by the fifteenth day all the white masses of hyphae have formed black pustules. Growth is confined entirely to the surface and interior of the medium with no aerial growth whatever. A faint zoning could be seen, but it was very slight.

Microscopic examination. The small white masses of hyphae just beginning to liberate spores in pustule form were picked out with a needle and examined under a dissecting microscope. They were found to contain globose or rounded bodies up to 2 mm. in diameter, single or aggregated, yellowish or reddish brown in colour. When torn with a needle the top half separates easily, leaving the lower portion as a cup, black inside owing to the mass of spores. In microtome sections

these globose or rounded bodies are seen to be pseudo-parenchymatous stromata containing pycnidial cavities (Plate V, fig. 1). A definite stroma composed of interwoven hyphae is formed in the culture medium, varying in depth from 0·22 mm. to 0·46 mm. The stromatic bodies are formed on this stroma. They are frequently irregularly lobed, and may contain one or several cavities. The whole body is covered when young with a weft of mycelium forming a thin compact felt,—a continuation of the felt of mycelium on the culture medium. The thickness of the stromatic tissue round the pycnidial cavities varies. In one stromatic body, which had a width of nearly 2 mm. and had three pycnidial cavities, the diameter of the cavities varied from 0·20 mm. to 1·17 mm. Spores are borne from a layer of cells on the pycnidial wall and are liberated by a rupture of the wall at any point, either at the top, or the sides, or at the base into the stroma or culture medium.

Spores. The length, including the terminal hyaline cells, was 24–36 μ, mean 30·3 μ; the coloured cells 16–25 μ, mean 19·8 μ; breadth 6–10 μ, mean 7·2 μ; pedicel not present; cilia 3 to 6 in number and up to 40 μ long. One abnormal spore measured 42 × 6 μ, with the coloured cells 30 × 6 μ; it had 5 cilia up to 18 μ long.

The hyphae were hyaline, septate, branched, and generally up to 3 μ in diameter. Irregularly swollen hyphae were present with a diameter at the swellings up to 8 μ.

Maize-meal agar. The slants were inoculated with spores from a pure culture. The mycelial growth is confined to the surface and interior of the medium, and by the fifth day it has extended 2·5 cm., and exhibits zoning. On the seventh day hyphae collect into small white masses at irregular intervals; and from the ninth day onwards these small white masses begin to produce spores in pustule form. With advancing growth the medium changes to a cream colour, and the whole surface becomes studded irregularly with black pustules of spores; in some tubes which show distinct zoning the pustules are more numerous at the denser bands, especially when the culture is old. No aerial growth is seen, and the hyphae ascend the sides of the tube for about 2 mm. only.

Microscopic examination. Under a dissecting microscope the black pustules are seen to arise from a body in the felt of mycelium on the medium. A pustule arises from each body in the form of a cone with a short thin stalk. The body is light brown in colour or mottled brownish and white, the mottling being caused by the white scattered hyphae of the thin felted layer which overlies the light brown wall. When young these bodies appear as small, pale yellowish protuberances

situated on the medium, elevating the thin web of mycelium which covers it. When older the web of mycelium is ruptured and the body appears quite prominent, globose or rounded.

In microtome sections, a definite stroma composed of interwoven hyphae is found in the medium in some tubes, varying in depth from 0·39 mm. to 0·61 mm., while in others there is no stroma but a loose network of hyphae, or pseudo-stroma, varying in depth from 0·26 mm. to 0·29 mm. The bodies from which the spores are extruded are all pycnidia, globose or spherical in shape, situated on the stroma or pseudo-stroma, or partly or completely embedded in the stroma or pseudo-stroma, or embedded in the culture medium (Plate VII, fig. 2). The pycnidia are completely enclosed by a pseudo-parenchymatous wall, which bears spores over all the interior surface, the spores being liberated by a break in the wall at the top or sides to the exterior, or at the base into the stroma or culture medium. The thickness of the wall may be constant in the one pycnidium or it may vary. In one pycnidium the thickness varied from 40 to 120 μ and in another from 10 to 20 μ. Below are examples of the pycnidia:

(*a*) *Pycnidium almost superficial, or partly embedded in the stroma.* Globose, 0·59 mm. wide and 0·42 mm. high, covered with a thin web of mycelium, wall varying in thickness from 40 to 120 μ; spores liberated at the base by an opening of the wall, 120 μ wide, into the stroma, filling an oval cavity 0·48 mm. wide and 0·39 mm. long.

(*b*) *Pycnidium completely embedded in the stroma.* Spherical, 0·33 mm. diameter, wall 20 to 40 μ thick.

(*c*) *Pycnidia embedded in the culture medium.* (1) Spherical, diameter 200 μ, wall 10 to 20 μ thick; spores liberated into the culture medium and filling a cavity about the same size as the pycnidium. (2) Spherical, diameter 180 μ, wall 15 to 20 μ thick; spores liberated by a split in the wall and filling a cavity in the medium, oval in shape, 0·39 mm. long and 0·26 mm. wide.

Spores. The length, including the terminal hyaline cells, was 25–32 μ, mean 28·9 μ; the coloured cells 18–22 μ, mean 19·5 μ; width 6–10 μ, mean 8·6 μ; pedicel not present; cilia 3 to 5 in number and up to 32 μ long. Many abnormal spores were present in culture, some having only one (Plate VII, fig. 1) and others only two coloured cells.

The hyphae were hyaline, septate, branched and generally up to 3 μ in diameter; irregularly swollen hyphae were also present with a diameter at the swellings up to about 5 μ.

The following table gives the dimensions of the spores on the various culture media.—

Media.	Range of length including terminal hyaline cells.	Mean length.	Range of length of coloured cells.	Mean length.	Range in width.	Mean width.
Oat agar.	25–35 μ	29·2 μ	17–23 μ	19·4 μ	6–10 μ	7·8 μ
French-bean agar.	24–36 μ	30·3 μ	16–25 μ	19·8 μ	6–10 μ	7·2 μ
Maize-meal agar.	25–32 μ	28·9 μ	18–22 μ	19·5 μ	6–10 μ	8·6 μ

The vegetative growth of this strain on the media stated differs entirely from that of *P. Theae* by the absence of the rich fluffy growth of aerial hyphae which occurs in cultures of the latter species and by the absence of the formation of spores on loose hyphae. In the different culture media the number of cilia varied from 3 to 6, while their length was up to 40 μ; they were frequently branched and the apices were not knobbed. As a rule, no pedicel was visible, and when present it was so short as to be almost imperceptible.

INOCULATIONS

Inoculations were made on detached tea leaves in a moist chamber and on leaves on the plant.

(1) 10 inoculations were made on detached tea leaves in a moist chamber with small pieces of Maize-meal agar culture; the leaves were washed in distilled water, wounded by shaving off a small area of the epidermis with a razor and the inoculum placed on the wounds. 9 inoculations failed and one was successful.

(2) This experiment was similar to the previous one but the inocula used were spores mixed with a few drops of nutrient solution. Four inoculations were tried and all were successful. In the inoculations regarded as successful in this series, the fungus attacked the wounded area and produced fructifications, but it did not extend into the surrounding tissue.

(3) With the same inoculum as No. 2, 6 inoculations were made on the upper surface and 6 on the lower surface of leaves without wounding, but all failed to take.

(4) Leaves of a bush in the open, were first washed in 0·1 per cent corrosive sublimate, then in distilled water, wounded by scraping the epidermis of the upper surface of the leaf with a needle and inoculated with small pieces of culture medium bearing spores. The leaf was enclosed in a large tube, the open end of which was plugged with cotton wool. 5 inoculations were made and all were successful.

(5) 4 inoculations were made on the lower surface, 2 on the upper surface and 3 on petioles, in a similar manner, but without wounding. All were failures.

(6) Young tea plants, about 6 to 7 inches high, were planted in a pot and covered with a bell glass. 8 inoculations were made on the upper surface and 4 on the lower surface of the leaves. Spores were germinated in hanging drops of nutrient solution and when the culture was 6 hours old and the spores had germinated the cover glass with the culture was placed on the leaf. All the inoculations were failures. 6 more inoculations were made on the upper and lower surfaces using pieces of Maize-meal agar culture and these too were failures.

58 inoculations were made in all,—17 on the unwounded lower surface of the leaf, 19 on the unwounded upper surface, 19 on the leaf after wounding and 3 on the petioles. The inoculations on the uninjured lower and upper surfaces of the leaf were all unsuccessful, while out of the 19 inoculations on the wounds, 10 were successful; those on the petioles were all failures.

A VARIANT STRAIN ON COCONUT

When diseased patches were being examined in the course of obtaining material for single spore cultures, a few pustules were found to contain spores which had no knobs at the apices of the cilia. These individual pustules were carefully examined to ascertain whether spores with knobbed cilia were present, but none were observed. The majority of pustules on the patch had spores with knobbed cilia, and these were examined to ascertain whether the unknobbed form occurred in them, mixed with the normal spores. So far as could be determined by microscopic examination, spores with knobbed cilia and spores with unknobbed cilia were in different pustules.

An examination of spores with unknobbed cilia gave the following results: the whole spore, including the terminal hyaline cells, measured 17–25 μ in length, mean 20·7 μ; the coloured cells 11–17 μ, mean 13·7 μ; width 5–8 μ, mean 6·4 μ; cilia not knobbed, 2 to 4 in number, usually 3, up to 40 μ long; pedicel 3 to 10 μ long. Normal spores of *Pestalozzia palmarum* gave the following dimensions: the whole spore, including the terminal hyaline cells, measured 15–25 μ in length, mean 20·2 μ;

the coloured cells 12–16 μ, mean 13·8; width 5–7 μ, mean 5·7 μ; cilia knobbed, generally about 20 μ long, occasionally attaining a length of 40 μ. The main difference between this spore and that of *P. palmarum* is that the cilia are long and not knobbed. Single spores were isolated and grown in pure culture in Maize-meal agar, Quaker Oat agar and French-bean agar.

CULTURES

Spore germination. Spores were sown in hanging drops of distilled water and standard nutrient solution. In both media the spores germinated from the lowest of the three coloured cells. *In distilled water*, in a culture four hours old the germ-cell in a few spores was losing its colour, and becoming spherical; a few spores had produced germ tubes 10 to 20 μ long and 3 to 3·5 μ wide. In a culture five hours old the majority of the spores had germinated, the germ tubes being up to 50 μ long. In a culture twenty-four hours old the spores had germinated with very few exceptions, and in those which had not germinated the germ-cell was colourless and swollen; in the majority of cases only one germ tube was produced, but many spores had two germ tubes, one on each side of the germ-cell. Very often a germ tube branched at the base (Plate X, fig. 1). The germ tubes were very long and septate, generally up to 3·5 μ wide, rarely reaching a width of 4 μ. *In nutrient solution*, the germ-cell begins to lose its colour when the culture is one hour old. In many cases a light band is seen across the germ-cell. In a culture four hours old, short germ tubes are present, 5 to 10 μ long. In a culture five hours old practically all the spores had germinated and possessed germ tubes up to 20 μ long and 5 μ wide. The germ-cell swells up to a diameter of about 9 μ, and gives out one germ tube, as a rule, but very frequently two, one on each side of the germ-cell. In a culture twenty-four hours old germ tubes were seen which had a diameter of 5·5 μ (Plate X, figs. 2,3). a few spores were seen, which had swollen and colourless germ-cells but had not produced a germ tube. The time taken for a spore to germinate in water and nutrient solution is therefore approximately four hours, but the actual time depends on the individual spore.

Spores were grown in pure culture in Maize-meal agar, French-bean agar and Quaker Oat agar. Details of the growth on these media are given below.

Oat-agar. The agar slants were inoculated with spores from a pure culture. On the third day the hyphae have grown 8 mm. from the centre of inoculation along the surface of the medium in an almost imperceptible film and then produced an aerial fluffy growth forming a com-

plete ring. On the fifth day distinct zones of aerial hyphae are present, while the zone first formed appears greyish owing to the production of spores on the free hyphae. In some slants the zones are more distinct than in others. Growth in all of them, however, was luxuriant, giving the appearance of a heavy white felt lying on the medium. With age, the colour of the medium changes into a pale amber or creamy buff colour. On the tenth day, in addition to the abundant production of spores on the loose hyphae, small black pustules of spores are seen scattered about in some tubes, especially at the sides where the culture meets the glass. Old cultures show black bands consisting of mycelium bearing spores, and a profusion of pustules on the white zones between them. The hyphae do not ascend the sides of the tube for more than a few millimetres; spores are produced on these hyphae.

Microscopic examination. Pieces of the culture medium bearing pustules were microtomed. In section the spores are seen to be extruded from pycnidia. In the culture medium a stroma composed of interwoven hyphae is formed, 0·12 to 0·26 mm. deep. The pycnidia are embedded in this stroma in abundance, and also occur on the stroma and in the loose felt of mycelium on the medium. They occur singly or in groups, distinct or with common walls. They vary in shape, but are usually, spherical, globose, or oval, 0·26–0·35 mm. diameter, or up to 0·42 × 0·26 mm. The wall varies in thickness from 15 to 25 μ.

Spores. The length, including the terminal hyaline cells, was 16–24 μ, mean 20 μ; the coloured cells 11–15 μ, mean 13 μ, width 5–7 μ, mean 6·2 μ; pedicel present, varying in length from 4 to 10 μ; cilia 2 to 4 in number, rarely 2, generally 3 and up to 32 μ long; apex of cilia not knobbed.

The hyphae were hyaline, septate, branched and up to 5 μ in diameter; the spore-bearing hyphae were from 2 to 3 μ in diameter.

French-bean agar. The agar slants were inoculated with spores from a pure culture. On the third day the hyphae have grown 1 cm. from the point of inoculation and end in a fluffy growth. Thence they grow again along the surface of the medium for about 6 mm., and on the fifth day form another puff of aerial hyphae. This method of growth represents zoning. On the sixth day the fluffy growth of the first ring appears greenish or greyish in colour, owing to the formation of spores on free hyphae. Growth continues, forming regular distinct zones of aerial hyphae until the end of the tube is reached, and spores continue to be formed on the hyphae at the loose zones. By the twelfth day the whole surface of the medium is covered with a thin felt of white mycelium with black bands at regular intervals. The medium be-

comes darker in colour with advance in growth. Hyphae ascend the sides of the tube for a few millimetres only. When the culture is fourteen days old very minute black bodies begin to make their appearance on the thin white felt, appearing quite conspicuous on the white background.

Microscopic examination. The minute black bodies that appear on the felted layer are pseudo-parenchymatous stromata, containing a single lobed pycnidial cavity. They are situated in the mycelium on the surface of the medium, and may be pulvinate, flattened pulvinate, or globose. They attain a diameter up to 1·04 mm., and a height of 0·45 mm. The wall varies in thickness from 20 to 140 μ, and this variation may occur in the same stroma. In other respects, they agree with the stromata formed on other media. A pseudo-stroma or loose network of hyphae is formed in the culture medium to a depth of 0·13 mm. to 0·21 mm.

Spores. The length, including the terminal hyaline cells, was 17–25 μ, mean 19·8 μ; the coloured cells 10–16 μ; mean 13 μ; width 5–7 μ, mean 6 μ; pedicel varying in length from 3–7 μ; cilia 2–4 in number, usually 3 and up to 30 μ long; apex of cilia not knobbed.

The hyphae were hyaline, septate, branched and up to 6 μ in diameter. Spores are produced at the ends of free hyphae 2–3 μ in diameter (Plate X, figs. 4,5), or on closely-septate hyphae 4–6 μ in diameter.

Maize-meal agar. The agar slants were inoculated with spores from a pure culture. On the third day the mycelium has grown 1 cm. from the point of inoculation along the surface of the medium and ends in a fluffy growth. Thence it grows again for about 6 mm. and ends in scanty fluffy hyphae. This method of growth suggests zoning. By the eighth day the whole surface of the culture medium is overrun with loose hyphae. Hyphae collect here and there into small inconspicuous tufts and form a minute white body in the centre of each. Later from the centre of each white body a black speck arises, which is a mass of spores extruded in pustule form. When the culture is eight days old fructifications begin to appear, spores being seen in pustule form or borne on loose hyphae. When the culture is ten to twelve days old the mycelial growth is a loose, thin, white layer lying on the medium, studded irregularly with black pustules of spores. As growth advances, the medium becomes cream coloured. Hyphae ascend the sides of the tube for a few millimetres only.

Microscopic examination. In microtome sections the pustules of spores are found to be liberated from pycnidia, or from pseudo-parenchymatous stromata containing pycnidial cavities. A pseudo-stroma

consisting of a loose network of hyphae, 0·13–0·26 mm. deep, extends from the surface of the medium inwards. The pycnidia and pseudo-parenchymatous stromata occur in the loose hyphae overlying the medium. The pycnidia are spherical or globose, up to 160 μ diameter internally, with a wall 10–25 μ thick. The pseudo-parenchymatous stromata vary in shape, but are generally globose or laterally oval; they are up to 0·78 mm. in diameter and 0·38 mm. high, and contain a single pycnidial cavity which is usually irregularly lobed, enclosed by a wall 60–80 μ thick. The length of the spore, including the terminal hyaline cells, was 17–28 μ, mean 20·9 μ; the coloured cells 10–18 μ, mean 13·3 μ; width 5–8 μ, mean 6·4 μ; pedicel present, varying in length from 3–10 μ; cilia 2–4 in number, generally 3 and up to 40 μ long; apex of cilia not knobbed. The hyphae were hyaline, septate, branched and up to 6 μ in diameter. Spores were also borne at the ends of free hyphae about 3 μ in diameter, and on closely-septate hyphae about 5μ in diameter, the spores on the latter arising alternately below each septum (Plate X, fig. 6).

The following table gives the dimensions of the spores in nature and on the various culture media:—

Media.	Range of length including terminal hyaline cells.	Mean length.	Range of length of coloured cells.	Mean length.	Range in width.	Mean width.
Leaf in nature.	17–25 μ	20·7μ	11–17 μ	13·7 μ	5–8 μ	6·4 μ
Oat-agar.	16–24 μ	20·0μ	11–15 μ	13 μ	5–7 μ	6·2 μ
French-bean agar.	17–25 μ	19·8μ	10–16 μ	13 μ	5–7 μ	6·0 μ
Maize-meal agar.	17–28 μ	20·9μ	10–18 μ	13·3 μ	5–8 μ	6·4 μ

The vegetative growth in all these media differs entirely from that of *P. palmarum* in the formation of fluffy aerial hyphae and the production of spores on the loose hyphae. In all the media the number of cilia varies from 2 to 4, but the usual number is three, and the length up to 40 μ; the apex of the cilium is not knobbed and it could not be made to knob by growing the fungus on tea and coconut leaves, sterilised by boiling, in Roux tubes. A pedicel is always present and varies in length from 3 to 10 μ.

As the majority of the pustules of spores on the original diseased patch were those of *P. palmarum* and the pustules of this variety of spore with unknobbed cilia were comparatively very few and scarce it may be assumed that this spore is only a variant strain of *P. palmarum* and not a new species.

Bernard described *P. palmarum* from Java and gives his spore dimensions as 20–28×5–8 μ; pedicel 3 to 6 μ long; cilia three, rarely two and of varying length. Comparing the dimensions of his species with this strain, there does not appear to be much difference between the two.

INOCULATIONS

On coconut. Five inoculations from a fresh culture were made on the lower surface of cut leaves in a moist chamber, and five inoculations on the upper surface. Six inoculations were made on the uninjured lower surface of leaves of coconut plants, and five inoculations on the leaves after wounding with pin pricks. When examined twenty-two days later only two out of the five wounded inoculations had succeeded, and in these the spots did not extend further than 2 mm. from the edge of the wounded area. All the other inoculations failed. The control was free.

On tea. Five inoculations were made on the lower surface of plucked leaves in a moist chamber and five on the upper surface. Five inoculations were also made on wounds made by shaving off a small area of the epidermis with a razor. When examined twenty-two days later, no penetration of the fungus was evident.

In all 21 inoculations were made on coconut leaves, 11 on the lower surface of the leaf, 5 on the upper surface, and 5 on the leaf after wounding. The inoculations on the uninjured upper and lower surfaces of the leaf were all unsuccessful, while out of the 5 inoculations on the wounds, 2 were successful.

15 inoculations were made on tea leaves,—5 on the lower surface, five on the upper surface and 5 on the leaf after wounding. All were unsuccessful.

SUMMARY

Pestalozzia Theae in culture produces a rich fluffy growth of aerial hyphae, which ultimately form a thick, dense, compact felt of white mycelium lying on the medium. Pycnidia and pseudo-parenchymatous stromata are found chiefly in the stroma formed in the culture medium. Spores are also borne in large numbers on the loose hyphae. The cilia of the spores are knobbed in nature and usually knobbed in culture.

Those spores which possessed cilia without knobs in culture could be readily made to produce knobs by growing them on sterilized tea or coconut leaves. The cilia grow very long in culture, attaining lengths of 45 μ in the French-bean medium and 55 μ in the Tealeaf-juice medium. The length of the pedicel varies from 3 to 10 μ.

In cultures of *Pestalozzia palmarum* the hyphae accumulate in tufts. Pycnidia are produced in abundance in the loose mycelium on the medium and only very few in the stroma in the culture medium. The pustules of spores extruded from pycnidia are smaller than those extruded from the pycnidia of *P. Theae*. Spores are not borne on loose hyphae. The spores have knobbed cilia in nature, but those produced in culture had cilia without knobs. The latter spores could not be made to produce cilia with knobs by growing them on sterilized tea and coconut leaves. Once the spore is taken into culture the cilia grow short, rarely reaching 12 μ in length. The pedicel is not present in some spores in culture; when present it is generally between 1 and 3 μ long, rarely attaining 5 μ in length.

The vegetative growth of the variant strain on tea differs from that of *P. Theae* by the absence of the rich fluffy growth of aerial hyphae and by the absence of the formation of spores on loose hyphae. The spore is also slightly larger in width and length. The cilia vary in number from 3 to 6, are frequently branched and not inflated at the tip. No pedicel is visible; or, if present, it is so short that it is almost imperceptible. One characteristic of this spore is the peculiar swelling at the junction where the cilia originate. Unlike the spores of *P. Theae* and *P. palmarum*, water is unfavourable as a medium for spore germination and when germinnation does occur in water it is irregular. In the absence of spore formation on free hyphae this form resembles *Pestalozzia palmarum*.

The vegetative growth of the variant strain on coconut differs from that of *P. palmarum* in the formation of fluffy aerial hyphae and the production of spores on the loose hyphae. The mean dimension of the spore is also slightly greater. The apex of the cilium is not knobbed in nature and in culture and could not be made to knob by growing the spore on sterilized tea and coconut leaves. The cilia grew very long in culture attaining a length up to 40 μ. A pedicel is always present in culture and varies in length from 3 to 10 μ. In the formation of spores on free hyphae, and the length of the cilia in culture, this form resembles *Pestalozzia Theae*.

47 inoculations were made with *P. Theae* on uninjured tea leaf—17 on the upper surface and 30 on the lower surface. Every inoculation failed. 6 inoculations were made on petioles and these two were un-

successful. 15 inoculations were made after wounding the leaf, of which 12 proved successes.

24 inoculations were made on the uninjured coconut leaf and all proved failures. 6 inoculations made after wounding were successes.

It would appear from these inoculations that *P. Theae* could infect tea and coconut leaves through a wound, but is unable to penetrate the healthy leaf under ordinary conditions.

26 inoculations were made with *P. palmarum* on the uninjured coconut leaf—17 on the lower surface and 9 on the upper surface. All were failures. 14 inoculations were made after wounding and all were successful.

32 inoculations were made on the tea leaf—21 on the upper surface and 11 on the lower surface after wounding and 10 inoculations without wounding. All proved failures.

From the inoculation experiments it could be deduced that *P. palmarum* could attack coconut leaves through a wound, but is unable to penetrate the healthy tissue under the condition of the experiment. The failure of the inoculation on the tea leaf indicates that the fungus is not parasitic on tea.

To Mr. T. Petch, B.Sc., B.A., Government Mycologist and Botanist, I have to express my gratitude for assistance in carrying out these investigations and in the preparation of the manuscript.

REFERENCES

Baker, C. F. Review of some Philippine Plant Diseases. The Philippine Agriculturist and Forester, III, No. 7, (1914).

Barret, O. W. The Philippine Agricultural Review, vol. V, No. 5. (1912).

Bernard, Ch. A propos d' une maladie des cocotiers causee par *Pestalozzia palmarum* Cooke. Bulletin Department de l' Agriculture aux Indes Néerlandaises No. 1, (1906).

Bernard, Ch. Sur quelques maladies de *Thea assamica*, de *Kickxia elastica* et de *Hevea brasiliensis*. Bulletin, Dept. de l' Agriculture aux Indes Néerlandaises No. 6, (1907).

Busck, A. Bulletin No. 38, U.S. Dept. of Agriculture, Division of Entomology, (1902).

Butler, E. J. Fungi and Disease in Plants. Calcutta and Simla, (1918).

Cooke, M. C. Some Indian Fungi. Grevillea, IV, p. 114 (1875-6).

Drieberg, C. Report on Coconut leaf diseases. Tropical Agriculturist, VIII, pp. 842, 843 ; IX, pp. 785-788,(1888-89).

Massee, G. Kew Bulletin, p. 106, (1898).

Petch, T. Administration Reports, Dept. of Agriculture, Ceylon, 1905, 1906, 1907, 1911-12.

Petch, T. The Diseases of the Tea Bush. London, (1923).

Potter, M. C. Coconut leaf disease. Tropical Agriculturist, vol. IX, p. 421, (1889).

Raciborski, Dr.M. Parasitische Algen und Pilze Java's, p. 32, (1910).

Richards, R. M. The Diseases and Pests of the Coconut Palm. Agricultural Bulletin, F.M.S., V, Nos. 8 and 9, (1906).

Stockdale, F.A. Bulletin, Dept. of Agriculture, Jamaica, V, (1907).

Stockdale, F. A. Fungus Diseases of coconuts in the West Indies. West Indian Bulletin, IX, No. 4, (1909).

Tanaka, Tyozaburo. Notes and Translations, New Japanese Fungi. Mycologia, IX, page 171, (1917).

DESCRIPTION OF THE PLATES

PLATE V. *Pestalozzia Theae* Sawada.

Fig. 1. Section through a pycnidium on the stroma formed in the medium liberating spores into the culture medium, ×42.

,, 2. Section through chambered pycnidia on the pseudo-stroma showing spores being liberated by a rupture of the wall and confined under the woolly hyphae, ×18.

,, 3. Section through a stromatic body containing pycnidial cavities, ×42.

,, 4. Section through a flask-shaped pycnidium on the stroma formed in the medium, ×230.

,, 5. Section through chambered pycnidia on the pseudo-stroma extruding spores to the top by a rupture of the wall, ×36.

, 6. Section through a pycnidium embedded in the stroma liberating spores into the culture medium, ×55.

PLATE VI. *Pestalozzia palmarum* Cke.

Fig. 1. Section through a group of pycnidia in the film of mycelium on the medium, ×173 (long axis of figure horizontal).

, 2. Section through a flask-shaped pycnidium in the film of mycelium on the medium, ×230.

,, 3. Section through a rectangular-oval pycnidium in the film on the medium with a small spheroidal pycnidium attached to it, ×260.

Fig. 4. Section through a globose pycnidium in the film on the medium showing spores being liberated by a break in the wall. A small spheroidal pycnidium at the side, ×335.

,, 5. Section through a spherical pycnidium embedded in the stroma formed in the medium, ×385.

,, 6. Section through a spheroidal pycnidium in the film on the medium, ×230.

PLATE VII. Variant Strain on Tea.

Fig. 1. Section through a stromatic body containing pycnidial cavities situated on the stroma, ×39.

,, 2. Section through a pycnidium embedded in the culture medium, ×62.

,, 3. Section through a pycnidium embedded in the culture medium liberating spores by a break in the wall into the culture medium, ×215.

, 4. Section through a young pycnidium showing pseudo-parenchymatous structure of the wall, ×250.

,, 5. Section through a pycnidiun partly embedded in the stroma liberating spores by an opening at the base into the stroma forming a cavity full of mature spores, ×38.

Figs. 6,7. Sections through pycnidia partly embedded in the stroma. One liberating spores to the exterior by a rupture of the wall at the side, ×35.

PLATE VIII. *Pestalozzia* spores in nature and in culture.

Fig. A. *Pestalozzia* spores on tea leaf in nature with knobbed cilia. One abnormal spore with 5 coloured cells, ×830.

,, B. *Pestalozzia* spores on coconut leaf in nature with knobbed cilia, ×830.

,, C. *Pestalozzia* spores from coconut in culture, ×830.

,, D. *Pestalozzia* spores with knobbed cilia grown from spores with unknobbed cilia, on sterilized tea leaf, ×830.

,, E. Spores of *Pestalozzia* on tea borne on hyphae in culture, ×830.

PLATE IX. *Pestalozzia Theae* Sawada and the variant strain on tea.

(a) Variant Strain.

Fig. 1. Abnormal spore with one coloured cell in Maize-meal agar culture, ×950.

Figs. 2, 4, & 5. Spores in culture, ×950.

Fig. 3. Abnormal spore with 5 coloured cells hatched on sterilised coconut leaf, ×950.

Figs. 6,7. Spores germinating in nutrient solution 17 hours old, ×950.

Fig. 8. Spore germinating in water, 60 hours, ×950.

(b) *P. Theae.*

Fig. 9. Spore germinating in Tea leaf juice agar, ×950.

,, 10. Spore germinating in nutrient solution 17 hours, ×950.

,, 11. Spore germating in distilled water 17 hours, ×950.

PLATE X. *Pestalozzia palmarum* Cooke and the Variant Strain on coconut.

(a) Variant Strain.

Fig. 1. Spore germinating in distilled water, 24 hours, ×950.

Figs. 2 & 3 Spores germinating in nutrient solution 24 hours, ×950.

,, 4 & 5 Spores borne on loose hyphae in French-bean agar culture, ×950.

Fig. 6. Spore borne on loose hyphae in Maize-meal agar culture, ×950.

(b) *Pestalozzia palmarum.*

Figs. 7 to 10. Spores germinating in nutrient solution. 24 hours, ×950.

,, 11 to 13. Spores germinating in distilled water. 24 hours, ×950

APPENDIX

Dextrose meat-extract agar.

Peptone	5	grm.
Sodium chloride	2·5	grm.
Lemco	2	grm.
Dextrose	10	grm.
Agar agar	7·5	grm.
Water	500	c.c.

Standard Nutrient solution.

Ammonium nitrate	1	grm.
Potassium biphosphate	·5	grm.
Magnesium sulphate	·25	grm.
Cane sugar	5	grm.
Water	100	c.c.
Iron chloride		trace.

Tea leaf-juice agar

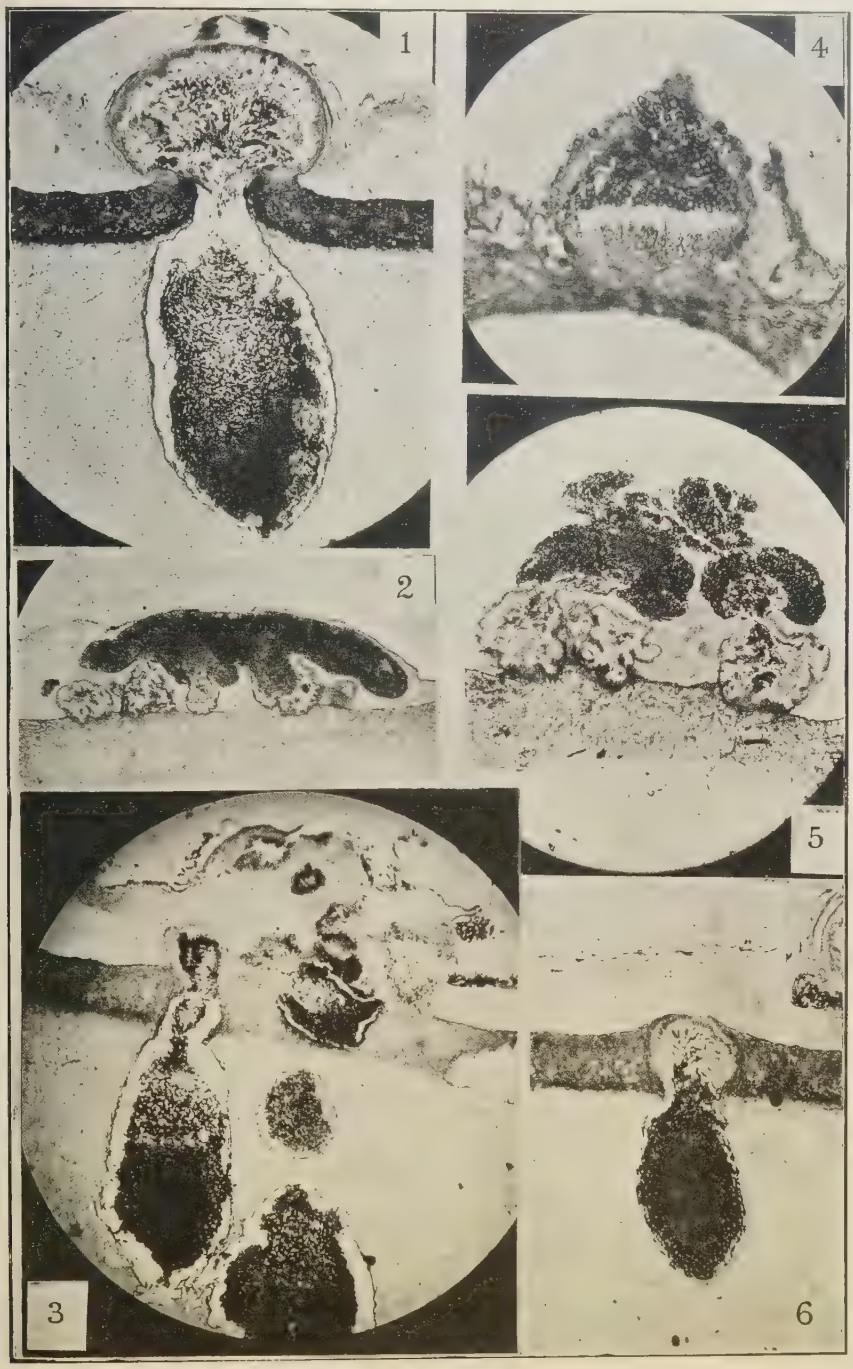
100 grammes of tea leaves were cut into pieces and boiled with 300 c.c. of water for forty minutes in a saucepan, water being added to make up for loss due to evaporation. The juice was filtered through a muslin cloth, 6 grammes of agar added and enough water to make up to 400 c.c. and mixed by boiling again.

Maize-meal agar. (25-5-250)

25 grammes of crushed Maize seed and about 250 c.c. of water were boiled in a saucepan for about forty minutes, water being added to make up for loss due to evaporation. 5 grammes of agar was dissolved by heating in a beaker in 150 c.c. of water. The Maize mixture was filtered through a muslin cloth, the content squeezed out, mixed with the agar, and water added to make up to 250 c.c.

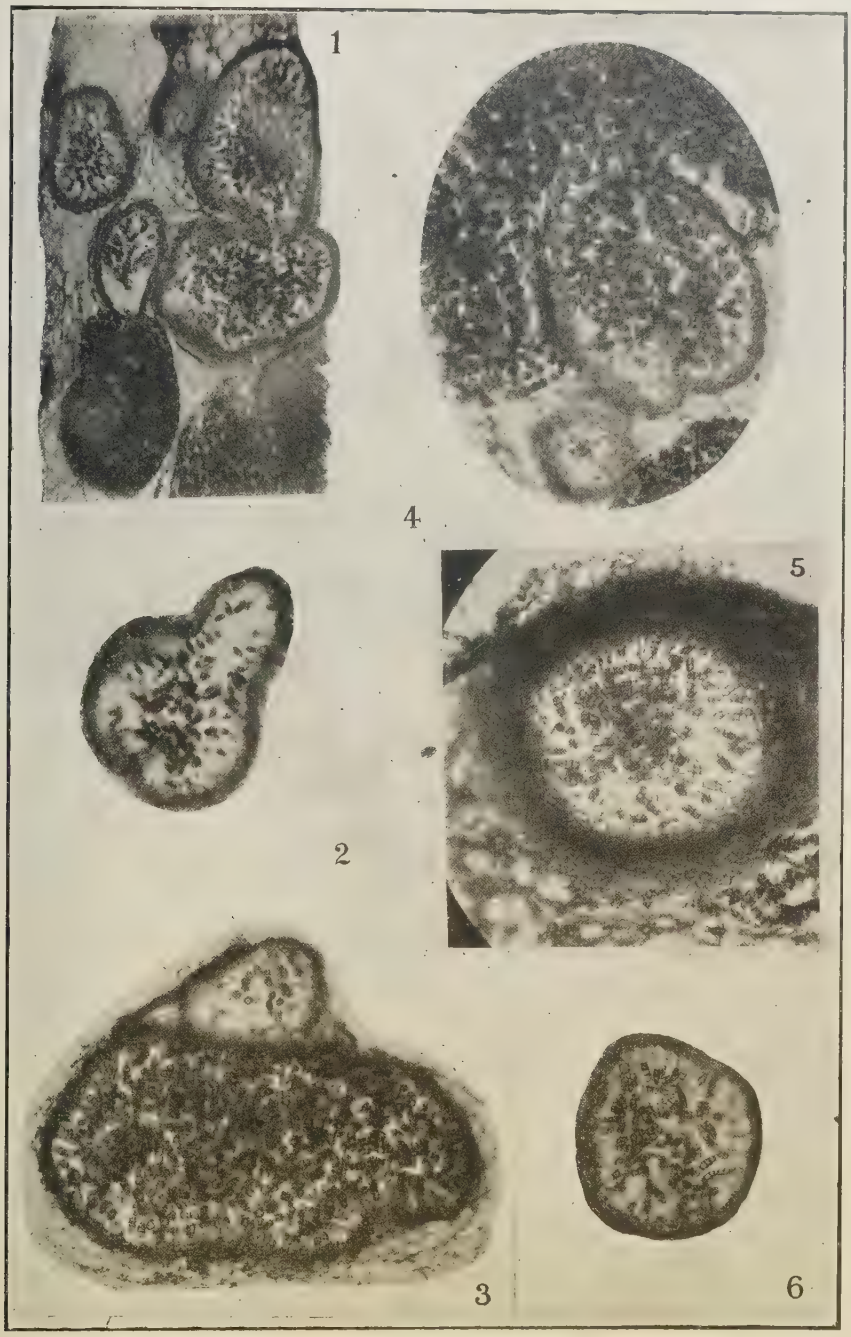
Quaker Oat-agar. (25-5-250). *French-bean agar* (25-5-250). Prepared as Maize-meal agar.

All the media were tubed and autoclaved at 115° for 20 minutes.



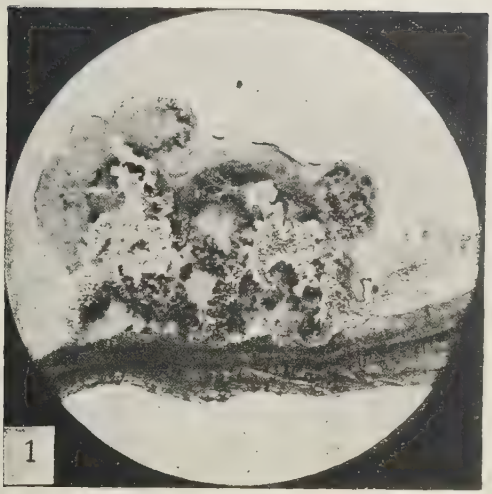
Photomicrograph by L. S. Bertus.

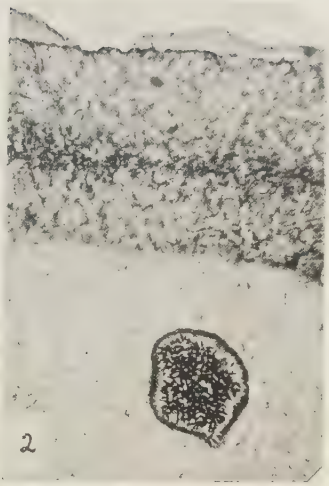
Pestalozzia Theae Sawada

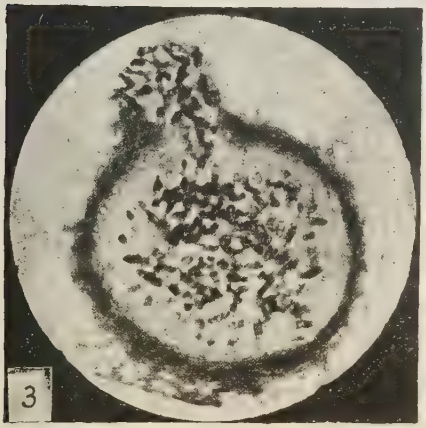


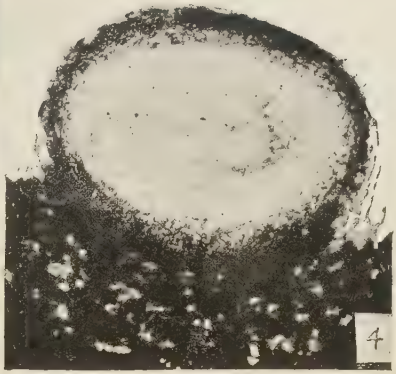
Photomicrograph by L. S. Bertus.

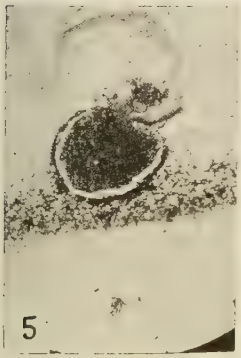
Pestalozzia Palmarum Cooke

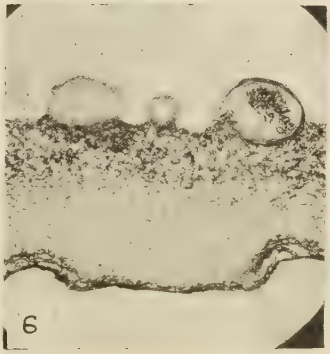


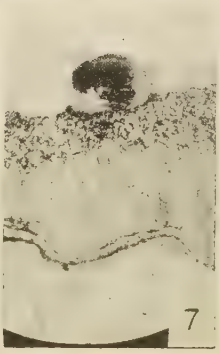






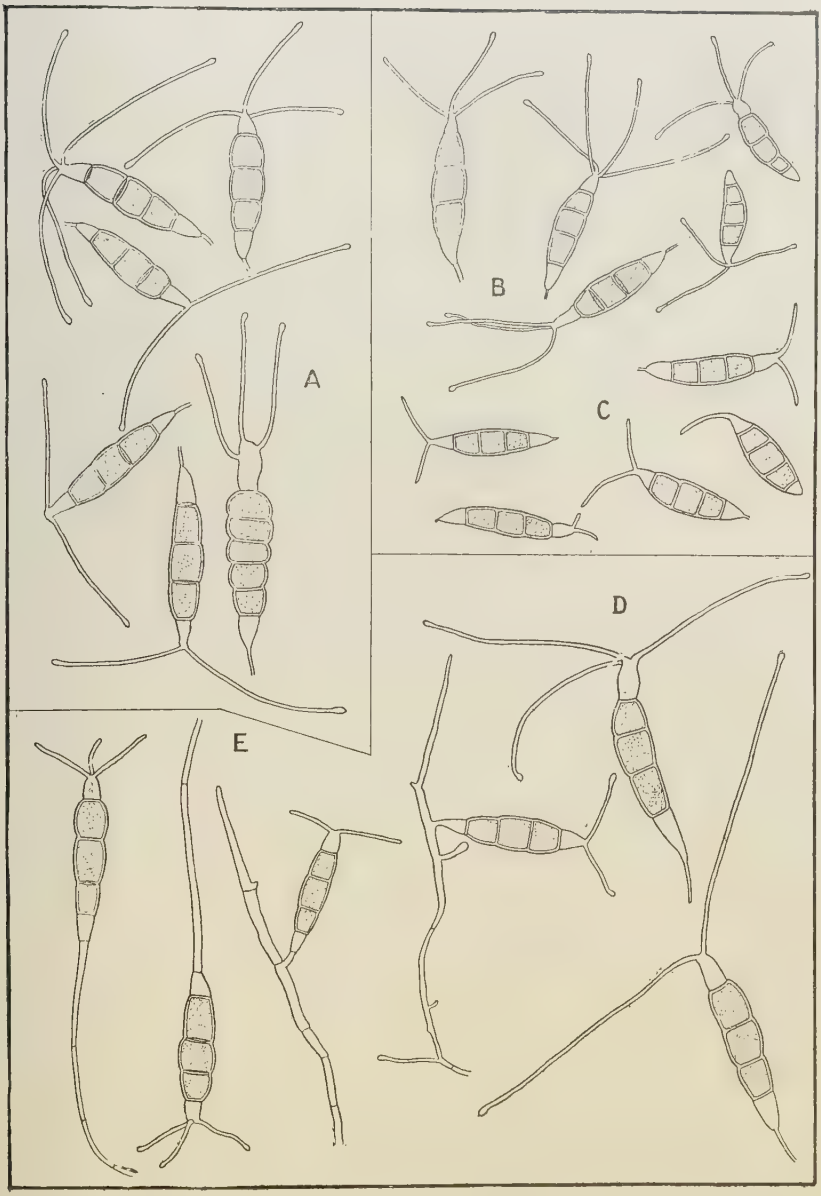




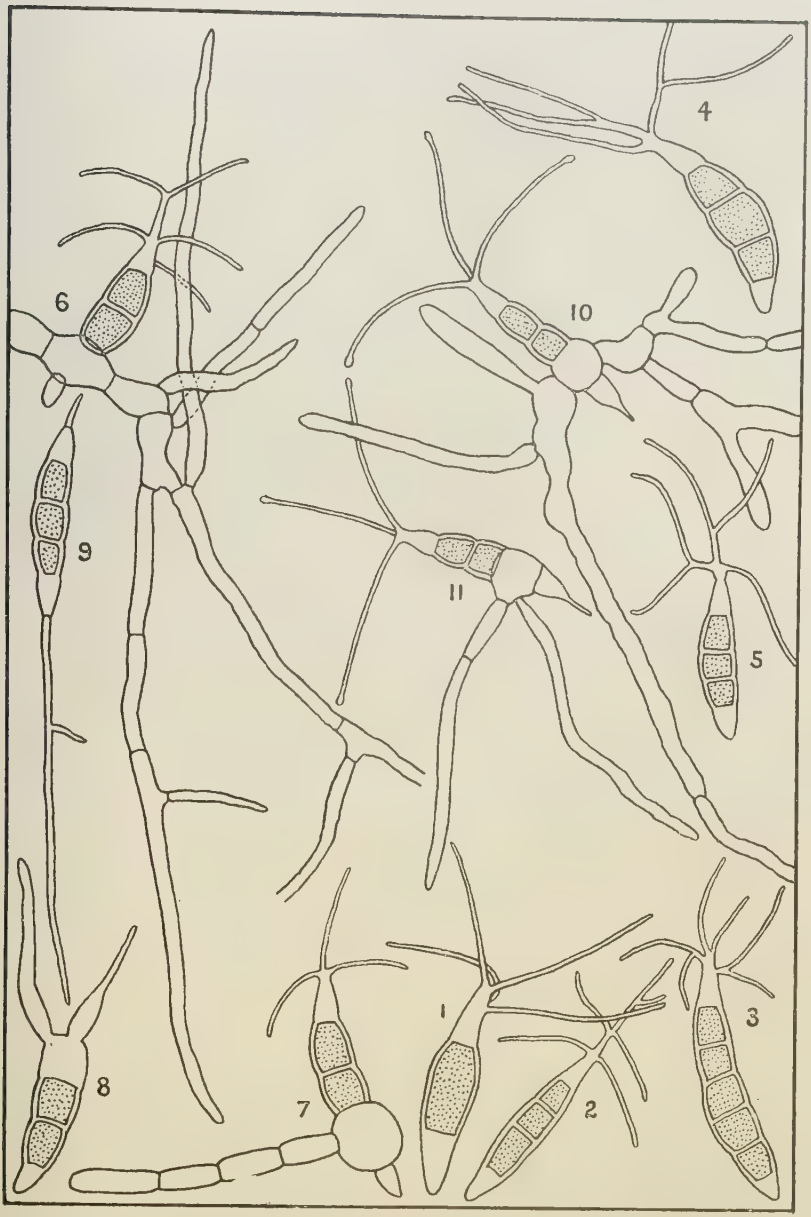


Photomicrograph by L. S. Bertus.

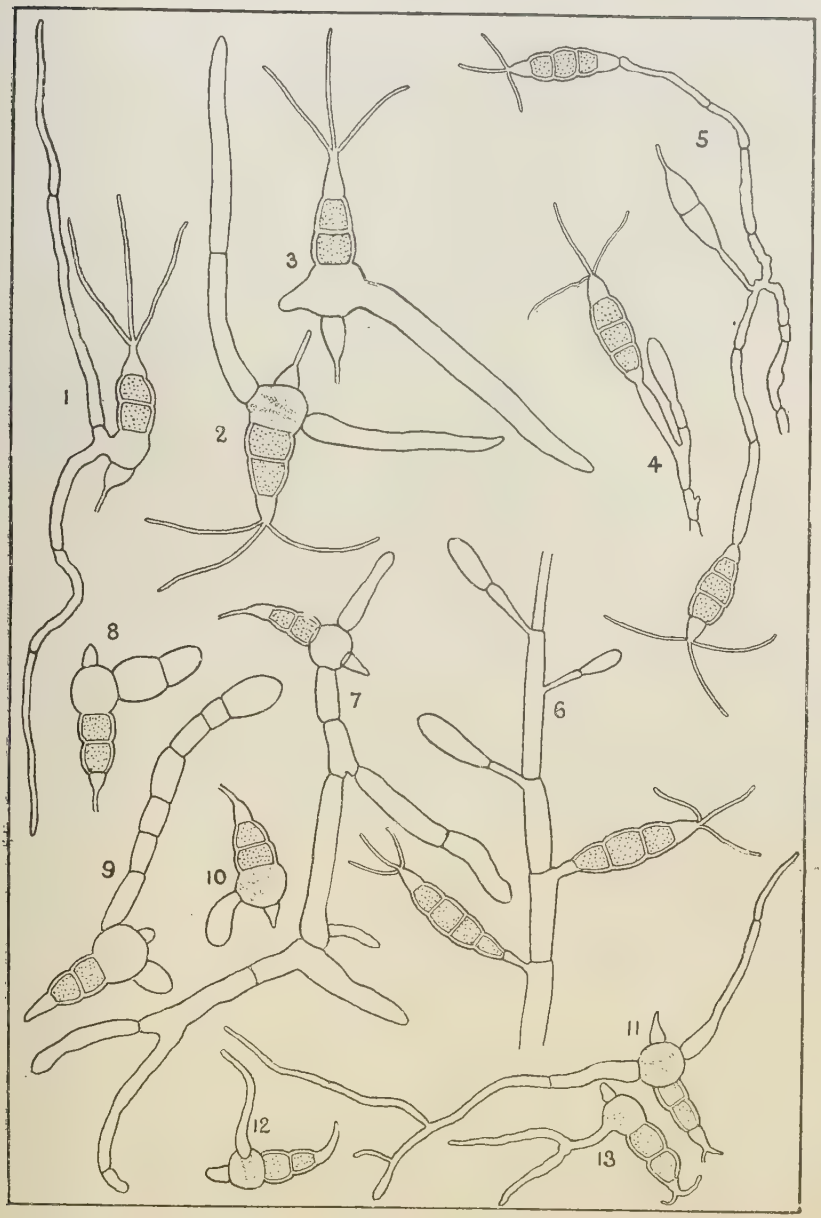
Variant strain on tea



Pestalozzia spores in nature and in culture



Pestalozzia theae. Sawada and the variant strain on tea



Pestalozzia palmarum Cooke and the variant strain on coconut

Some Observations on the Oospores of Phytophthora Species *

BY

W. C. Lester-Smith, B.A., Dip. Agric. (Oxon)

WITH TWO PLATES

INTRODUCTION

Leonian, in his recent work (6), has used physiological growth characters almost entirely for the separation of the various species of *Phytophthora*. Until the appearance of his paper, the measurable characters of the various spore forms were the chief morphological grounds upon which such work had been based. Especially is this true in the case of the sexual spores (oospores) of those species in which they are known. The factors which actually determine the production of these sexual reproductive bodies are not yet definitely apparent. *Phytophthora palmivora* Butler, *P. faberi* Maublanc, and *P. nicotianae* Br. de Haan are three forms about the oospores of which little or nothing is known. In view of this, any addition to our knowledge of the size and development of the oospores of these forms is both valuable and of interest. *P. palmivora* and *P. faberi* are considered by Butler (3) to be at most strains of one species, and this view is held by Ashby and Gadd. In this paper forms of this species are, for simplicity, termed strains of *P. faberi*; but, as is mentioned later, the species should be known as *P. palmivora* Butler. The results here set out confirm this view as the oospores of each of the three strains of *P. faberi* used are alike in size and development.

THE OOSPORES OF P. FABERI

Ashby (1), in 1922, was the first to record oogonia and antheridia of *P. faberi*. Oospores, the mean size of which was 23.3 microns,

* These observations were made during the tenure by the author of a Senior studentship, under The Empire Cotton Growing Corporation, at the Imperial College of Tropical Agriculture, Trinidad, 1924-1925. The work was undertaken at the suggestion of Professor S. F. Ashby, B. Sc., Microbiologist at the College.

The author is very much indebted to him for his kind and most able guidance throughout the work.

developed in mixed cultures of (i) *P. faberi* and *P. palmivora*, (ii) *P. faberi* and a species of *Phytophthora* isolated from cotton in St. Vincent, and (iii) *P. faberi* and *P. parasitica* from castor in India. *P. palmivora* and the species from cotton in St. Vincent are apparently identical, and they differ from *P. faberi* only in definite growth characters. As a result of the formation of oospores in the mixtures (i) and (ii), Ashby suggested the possibility of heterothallism in *P. faberi*. This, however, was not supported by the development of oospores of *P. faberi* in mixture (iii).

The following sentences which give the key to the use of the term heterothallism in this paper are inserted for the sake of clarity. Blakeslee (2), working with some of the *Zygomycetes*, demonstrated that certain species consisted of two strains or races which, when grown apart, produced only asexual spores, but formed sexual spores when hyphae from the two physiologically different mycelia were allowed to come into contact. Such species he termed heterothallic species in contrast to the homothallic species producing sexual spores from the single mycelium. Furthermore, in cases in which sexually opposite strains of two different species were allowed to come into contact only attempts at hybridization took place, and in no case was a sexual spore formed. In cases in which like strains of different species were allowed to come into contact, no attempts at hybridization were noted. *P. parasitica* was at this time regarded as a distinct species, but, according to Leonian (loc. cit), *P. parasitica*, *P. palmivora*, *P. faberi*, and several other species are regarded as belonging to the same species-group (*P. omnivora*). He admits, however, the necessity of the group being split up into the two sub-groups (a) *Parasitica*, including amongst others *P. parasitica* and *P. terrestris*, and (b) *Colocasiae*, to include *P. faberi*, *P. palmivora*, etc. If this arrangement be accepted and heterothallism be regarded as probable in the *colocasiae* sub-group, all the homothallic forms belonging to the species-group *P. omnivora* will of necessity belong to the *parasitica* sub-group. As far as present information goes, this is apparently so; and, if this be correct, the production of oospores by a *faberi* strain in mixed culture with a homothallic *parasitica* strain cannot be interpreted by a theory of heterothallism. Gadd (5), in 1924, strongly inclined to the hypothesis of heterothallism in *P. faberi*, but did not grow strains of this fungus in mixed cultures with a distinct species or with a known homothallic strain.

The purpose of the observations now reported was to repeat and extend observations on oospore production in cultures of *P. faberi* strains mixed with *P. parasitica* strains. If strains of *P. faberi* produce oospores in such mixtures heterothallism would not be indicated in

P. faberi. Another explanation appears to be called for in this case and the following theory is put forward :—that the formation of oospores is due to the influence of the one vegetation on the other, acting through its effect on the medium or on certain constituents of the medium.

Strains used in the mixed cultures

Some seven presumed strains of *P. parasitica* and three of *P. faberi* were available, and mixed cultures of each of the *parasitica* strains with each of the *faberi* strains were grown. A number of the *parasitica* strains, however, failed to produce oospores in pure cultures or developed them too scantily to afford reliable data in regard to mean size and variation. The data recorded, therefore, are restricted to three *parasitica* strains which developed oospores in pure cultures in numbers sufficient to enable their mean size and range to be determined. The mixed cultures of these three strains with each of the three *faberi* strains yielded oospores in ample numbers.

The three *parasitica* strains. (Subsequently referred to as *parasitica* I, II, and III.)

I. *P. terrestris* Sherb.

A culture from W. S. Beach of Pennsylvania University, supplied to him by Sherbakoff, and isolated from tomato fruit in Florida affected by " buckeye " disease. This species is regarded by Ashby, Bewley, and Dastur as indistinguishable from *P. parasitica* Dast. and is treated here as a *parasitica* strain.

II. *P. parasitica* strain.

A strain isolated by Ashby in 1923 from the vascular system of a banana plant in Trinidad which was attacked by a *Fusarium* wilt (Panama disease.)

III. *P. parasitica* strain.

A strain isolated in 1920 by Miss E. M. Wakefield from a " boll-rot " of cotton in Montserrat.

The three *faberi* strains (all isolated by Prof. Ashby and subsequently referred to as *faberi* I a and b, 2 a and b, and 3.)

1. *P. faberi* strains, a and b.

Two isolations made in 1924 and 1925 respectively, from " pod-rot " of cacao in Trinidad.

2. *P. faberi* strains, a and b.

Two isolations, maintained in pure culture since 1919, from a " bud-rot " of the coconut palm in Jamaica.

3. *P. faberi* strain.

A strain isolated in 1922 from a " boll-rot " of cotton in St.Vincent.

Media

Lima-bean, maize-meal and quaker-oats agars were used as the standard media. Their composition was :—lima-bean, forty to fifty grams of ground dry beans ; quaker oats, twenty-five grams ; maize-meal, twenty-five grams of American (germ-free) corn-meal. The agars were prepared from these substances by the addition of five hundred cubic centimetres of tap or distilled water and the whole heated to boiling-point. Seven and a half grams of " Bacto " agar were added and dissolved, the whole strained through muslin or cheese-cloth and sterilized in an autoclave at 12 to 15 lbs. pressure for 20 minutes.

Pure Cultures

Pure cultures of the *parasitica* strains I, II, and III developed oospores abundantly on bean-agar after from two to three months, growth at room temperature. The mean room temperature of the laboratory where the cultures were kept was about 79° F, and the variation from 70 to 86°F. On quaker-oats agar all three strains produced oospores much less freely, and only scantily or not at all on maize-meal agar. Pure cultures of the *faberi* strains failed to develop oospores on all media, a finding which is in agreement with the observations of Ashby and Gadd. Tables A and B give all the available data for the pure cultures of the *parasitica* strains I, II, and III.

TABLE A

parasitica strain.	No. measured.	Medium and temp.	Age of culture in mths.	Mean in microns.	Standard error.	Range.
parasitica I.						
(1)	200	Bean agar. Ice chest.	2	18·24	·253	14·4—22·5
(2)	113	Quaker oats. agar. Room temp.	5¼	17·99	·185	13·0—22·5
(3)	50	Bean agar. Room temp.	5	18·6	·384	14·4—22·5
parasitica II.						
(4)	50	Bean agar. Room temp.	4½	18·24	·437	14·4—21·6
parasitica III.						
(5)	34	Bean agar. Room temp.	5¾	18·3	—	15·6—21·8
	363			91·37		
				18·27		

TABLE B

frequency arrays

Serial Nos. of cultures. Microns.	1.	2.	4.	Totals.
13—14·9	11	1	4	16
15—16·9	35	19	13	67
17—18·9	114	41	17	172
19—20·9	26	41	9	76
21—22·9	14	11	7	32
23 or over	nil.	nil.	nil.	—
Totals	200	113	50	363

Mixed Cultures

The mixed cultures are numbered serially throughout. Tables C and D give all the data for the mixed cultures of the *faberi* strains with *faberi* strains.

TABLE C

Faberi *strain* + faberi *strain mixtures*

1a and 1b are strains from cacao.
2a and 2b are strains from coconut.
3 is a strain from cotton.

Serial No.	Mixtures.	Medium & temp.	Age of culture in mths.	No. of oospores measured.	Place on slant.	Mean microns.	Standard error.	Range in microns.
1	1a + 2a	Bean agar. Ice chest.	1½	100	Middle.	21·48	·230	18·0—28·8
2	1a + 2b	Bean agar. Ice chest.	1½	100	Middle.	22·25	·292	16·0—28·8
3	1b + 2a	Bean agar. Ice chest.	1	100	Middle.	21·9	·224	18·0—28·8
4	1b + 2a	Bean agar. Room temp.	1½	132	Apex & Middle.	22·07	·300	17·1—30·6
5	1b + 2b	Bean agar. Ice chest.	1	100	Middle.	22·04	·239	18·0—28·8
6	1b + 2b	Bean agar. Room temp.	1½	100	Middle.	22·63	·204	18·0—28·8
7	1a + 3	Bean agar. Ice chest.	1½	100	Middle.	22·27	·210	18·0—27·0
8	1b + 3	Bean agar. Ice chest.	1	150	Middle.	21·08	·158	16·2—25·2
9	1b + 3	Bean agar. Room temp.	1	100	Middle.	22·99	·243	17·1—29·7
				982		198·71		
						22·08		

TABLE D

Frequency arrays

Serial Nos.	1.	2.	3.	4.	5.	6.	Totals. 1—6	7.	8.	9.	Totals. 7—9	Complete totals. 1—9
Microns.												
Under 17	—	1	—	—	—	—	1	—	1	—	1	2
17—18·9	9	9	11	13	10	5	57	7	24	4	35	92
19—20·9	24	17	16	25	21	14	117	16	39	10	65	182
21—22·9	25	30	39	46	34	34	208	30	55	44	129	337
23—24·9	30	25	23	34	20	31	163	38	23	20	81	244
25—26·9	9	14	8	8	9	11	59	7	8	15	30	89
27—28·9	3	4	3	5	6	5	26	2	—	5	7	33
29—30·9	—	—	—	1	—	—	1	—	—	2	2	3
Totals	100	100	100	132	100	100	632	100	150	100	350	982

Tables E and F give all the data for the mixed cultures of the *parasitica* strains with *faberi* strains.

TABLE E

1a & 1b are *faberi* strains from cacao.
2a & 2b are *faberi* strains from coconut.
3 is a *faberi* strain from cotton.
I is a *parasitica* strain from tomato. (*P. terrestris*).
II is a *parasitica* strain from banana.
III is a *parasitica* strain from cotton.

Serial No.	Strains Mixed.	Medium and temp.	Age of culture in mths.	No. of oospores measured.	Place on slant.	Mean in microns.	Standard error.	Range in microns.
10	1 & 1a	Maize-meal. Ice chest.	2	50	Apex.	20·58	·288	16·2—28·8
11	1 & 1a	Quaker oats. Room temp.	3½	50	Apex.	21·12	·304	16·2—25·2
12	1 & 1b	Quaker oats. Ice chest.	2	50	Apex.	19·76	·327	17·3—25·9
13	1 & 1b	Quaker oats. Room temp.	3	50	Apex.	19·64	·231	16·2—23·4
14	1 & 1b	Maize-meal. Ice chest.	2	50	Apex.	20·54	·295	16·2—26·4
15	1 & 1b	Maize-meal. Ice chest.	4	100	Apex.	21·13	·242	14·4—28·8
16	1 & 1b	Maize-meal. Ice chest.	4	100	Apex.	21·75	·322	14·4—30·6
17	1 & 1b	Bean. Room temp.	2	50	Apex.	19·2	·227	16·2—23·4
18	1 & 2a	Bean. Ice chest.	1	100	Apex.	19·28	·142	16·2—25·2
19	1 & 2a	Bean. Room temp.	1	100	Apex.	19·53	·187	15·3—24·3
20	1 & 2a	Bean. Room temp.	1	100	Middle.	18·62	·153	14·4—23·4

TABLE E—(*Contd.*)

Serial No.	Strains Mixed.	Medium and temp.	Age of culture in mths.	No. of oospores measured.	Place on slant.	Mean in microns.	Standard error.	Range in microns.
21 i	1 & 2a	Maize-meal. Ice chest.	5½	114	Upper-half.	23·54		18·2—31·2
ii	1 & 2a	Maize-meal. Ice chest.	5½	67	Upper-half.	22·3		18·2—27·3
iii (i & ii)	1 & 2a	Maize-meal. Ice chest.	5½	181	Upper-half.	23·08		18·2—31·2
22	1 & 2b	Bean. Ice chest.	1	100	Apex.	19·33	·148	16·2—22·5
23	1 & 2b	Bean. Room temp.	1	100	Apex.	19·38	·204	14·4—25·2
24	1 & 2b	Maize-meal. Ice chest.	5½	37	Upper-half.	23·6		18·2—31·2
25	1 & 3	Maize-meal. Ice chest.	2	50	Apex.	24·02	·329	19·8—28·8
26	1 & 3	Quaker oats. Room temp.	3½	50	Apex.	21·64	·705	18·0—28·8
27	1 & 3	Bean. Ice chest.	1	100	Apex.	19·25	·171	14·4—24·3
28	1 & 3	Bean. Room temp.	1	100	Apex.	18·34	·181	14·4—25·2
29	1 & 3	Maize meal. Ice chest.	5½	86	Upper-half.	22·92	—	17·0—33·8
30 II	& 1a	Maize meal. Ice chest.	2½	50	Apex.	22·68	·467	16·2—31·5
31 II	& 1a	Quaker oats. Room temp.	3½	50	Apex.	20·72	·583	14·4—30·6
32 II	& 1b	Bean. Room temp.	3	50	Apex.	18·88	·190	16·2—21·6
33 II	& 1b	Quaker oats Ice chest.	2	50	Apex.	20·76	·348	15·3—32·4
34 II	& 1b	Quaker oats. Room temp.	3½	50	Apex.	21·0	·408	16·2—28·8
35 II	& 1b	Maize-meal. Ice chest.	2	50	Apex.	23·44	·558	18·0—32·4
36 III	& 1a	Maize-meal. Ice chest.	2¾	50	Apex.	22·52	·632	14·4—32·4
37 III	& 1b	Bean. Room temp.	2½	50	Apex.	18·04	·242	14·4—21·6
38 III	& 1b	Quaker oats. Room temp.	4	36	Apex.	20·05	·316	18·0—25·2
39 III	& 1b	Quaker oats. Ice chest.	2	50	Apex.	20·46	·303	17·0—24·3
40 III	& 1b	Maize-meal. Ice chest.	2	50	Apex.	21·2	·303	18·0—25·2

Note.—In culture No. 21 the sub-groups i and ii represent separate samples from the one culture, sub-group iii is the complete total for these first two. I am indebted to Prof. Ashby for the results of this culture and also of cultures Nos. 24 and 29 none of which had produced oospores when I left the College.

TABLE F

Serial Nos.	10	11	12	13	14	15	16	17	Totals 10—17	18	19	20	21 (iii)	22	23	24	Totals 18—24
Microns under 15.	—	—	—	—	—	1	1	—	2	—	—	2	—	—	3	—	5
15—16·9	1	1	—	3	1	2	4	5	17	4	8	12	—	9	9	—	42
17—18·9	14	9	16	20	15	22	15	24	135	49	44	64	8	36	39	2	242
19—20·9	12	10	16	11	8	17	24	11	109	35	19	11	37	32	25	7	166
21—22·9	20	18	9	14	20	37	26	8	152	10	22	9	53	23	16	10	143
23—24·9	2	8	2	2	4	14	11	2	45	1	7	2	44	—	7	7	68
25—26·9	—	4	7	—	2	6	11	—	30	1	—	—	17	—	1	4	23
27—28·9	1	—	—	—	—	1	7	—	9	—	—	—	16	—	—	3	19
29—30·9	—	—	—	—	—	—	1	—	1	—	—	—	4	—	—	3	7
31—32·9	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—	1	3
over 33	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	50	50	50	50	50	100	100	50	500	100	100	100	181	100	100	37	718

General Observations

That oospores of the *faberi* strains were produced in these mixed cultures seems very evident. Frequency arrays show definitely that in the mixtures of the cultures of *P. faberi* from cacao with the three *parasitica* strains oospores of *P. faberi* were present in cultures Nos. 10, 14, 15, 16, 30, 31, 33, 34, 35, 36, and probably in cultures Nos. 11, 12, 38, 39, and 40. It is also evident that the great majority of oospores in cultures Nos. 17, 32 and 37 were due to *parasitica* alone, and these, it should be noted, were on bean-agar. In the mixtures of the *faberi* strain from cotton (St. Vincent) with a *parasitica* strain it is practically certain that all the oospores in culture No. 25 were those of *faberi*; and also that the great majority of those in cultures Nos. 26 and 29 were *faberi*. In cultures Nos. 27 and 28, both on bean-agar, the majority of the oospores were those of *parasitica*.

FREQUENCY ARRAYS

25	26	27	28	29	Totals 25—29	30	31	32	33	34	35	Totals 30—35	36	37	38	39	40	Totals 36—40	Complete Totals 10—40
—	—	1	3	—	4	—	1	—	—	—	—	1	2	4	—	—	—	6	18
—	—	9	19	—	28	1	7	6	2	3	—	19	2	12	—	—	—	14	120
—	8	43	45	3	99	6	18	27	9	11	3	74	3	27	12	18	9	69	619
4	6	26	15	19	70	4	6	10	14	9	8	51	12	2	14	12	14	54	450
10	20	17	14	18	79	18	6	7	17	17	8	73	13	5	6	10	17	51	498
14	12	4	3	35	68	9	1	—	5	3	8	26	4	—	2	10	5	21	228
17	3	—	1	6	27	6	4	—	1	4	11	26	6	—	2	—	5	13	119
5	1	—	—	2	8	3	5	—	1	3	5	17	2	—	—	—	—	2	55
—	—	—	—	1	1	2	2	—	0	—	2	6	3	—	—	—	—	3	18
—	—	—	—	1	1	1	—	—	1	—	5	7	3	—	—	—	—	3	14
—	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	1
50	50	100	100	86	386	50	50	50	50	50	50	300	50	50	36	50	50	236	2,140

The inoculations for the mixed cultures were made, as also in the case of the pure cultures, with fragments of agar from pure cultures on agar slants. With the pure cultures the inoculation was, as far as possible, made on the middle of the slant. With the mixed cultures the two inoculations were, as far as possible, made equidistant from each other and from the top or bottom of the slant respectively. In the case of the mixtures of the *faberi* with the *parasitica* strains, the *faberi* strain was in every case inoculated first, and on the centre of the lower half of the slant, the *parasitica* strains being inoculated on the centre of the upper half. In the tables of these mixtures (tables C and E), the position on the slant from where the oospores measured were obtained is shown. This is a point of importance, as, in the case of the oospores obtained from the apices of the slants, one would expect the mean to show a low tendency due to a predominance of the oospores of the *parasitica* strains; and such is in most cases apparent.

Conclusions

From the results of these cultures it is apparent that the strains of *parasitica* used, in pure culture, give a mean size for the oospores of approximately 18.0 microns with a range of from 13·0 to 22·9 microns. The results of the mixtures of the *faberi* strains alone may be regarded as equivalent to results, could they be obtained, of pure cultures of *faberi* strains ; and these results give a mean size for the definitely amphigynous oospores of approximately 22·0 microns with a range of from 16·0 to 33·8 microns. In the mixtures of the *parasitica* with the *faberi* strains, there is evidence of an increase in the mean size of the oospores with the age of the culture. This was especially noticeable in cultures Nos. 21, 24, and 29 in table E which are five and a half months old ; and there was no indication of this in the pure cultures of the *parasitica* strains (table A). This rather indicates that oospores of the *faberi* strains go on developing after those of the *parasitica* strains have ceased ; and this tendency was to a slight extent noticeable in the mixed cultures of the *faberi* strains alone (table C). It was also apparent that bean-agar favoured the production of *parasitica* oospores and maize-meal agar the production of *faberi* oospores ; this makes the latter medium preferable for mixed cultures and confirms Gadd's good results with it.

The following short table, extracted from tables E and F, shows the results on maize-meal agar of each of the three *faberi* strains mixed with *parasitica* strains in those cultures where it was evident that the great majority of the oospores measured were those of the *faberi* strains :—

Serial No.	*faberi* strain.	*parasitica* strain.	Age of culture (mths).	No. of oospores.	Mean on microns.	Range.
16	1b, cacao	I, tomato	4	100	21·75	14·4—30·6
30	1a, cacao	II, banana	2½	50	22·68	16·2—31·5
35	1b, cacao	II, banana	2	50	23·44	18·0—32·4
36	1a, cacao	III, cotton	2¾	50	22·52	14·4—32·4
21 (iii)	2a, coconut	I, tomato	5⅛	181	23·08	18·2—31·2
24	2b, coconut	I, tomato	5½	37	23·60	18·2—31·2
25	3, cotton	I, tomato	2	50	24·02	19·8—28·8
29	3, cotton	I, tomato	5½	86	22·92	17·0—33·8
					8)184·01	
					23·00	

In two of these mixed cultures oospores of the *parasitica* strain were definitely present (indicated by a minimum of 14·4 microns) and tended to lower the mean size and widen the range. This table shows conclusively that all three *faberi* strains have produced oospores abundantly when grown independently with *parasitica* strains. It also furnishes almost definite proof that the strains from cacao, Trinidad, "bud-rot" of coconut, Jamaica, and "boll-rot" of cotton, St. Vincent, belong to one species.

These results compare very favourably with those of Ashby (loc. cit., table on page p. 261, cultures Nos. 8 to 11, and 16). For his mixed cultures, sub-cultures of the same isolation from coconut were used but with a different isolation from cacao growing in Grenada. They are also comparable with the results of Gadd (loc. cit., table 6, p. 73). The description and naming of the coconut and palmyra strain by Butler (*Pythium palmivorum*, referred by him to *Phytophthora* in 1919 dates from 1907, and the description and naming of the cacao strain by Maublanc (*Phytophthora faberi*) dates from 1909. The species should, therefore, on grounds of priority be known as *Phytophthora palmivora* Butler.

It is not considered that these results show any definite evidence of hybridism. That hybridisation had not taken place seemed apparent during the examination of the cultures and measuring of the oospores ; and this, it is considered, is brought out quite clearly in the frequency arrays. With other members of the *Phycomycetes*, Blakeslee (loc. cit.) never obtained perfect hybrid sexual spores and Burgeff (3), only by means of a very elaborate technique, obtained graft hybrids which never produced any sexual spores. In view of these facts, the omission of any consideration of hybridism is perhaps justifiable.

It is held that oospores of all the *faberi* strains were formed in these mixed cultures, thus substantiating the views of Ashby and Gadd. The abundant evidence afforded by the cacao strain of *P. faberi*, and the evidence from cultures Nos. 25, 26 and 29 in table F that the *faberi* strain from cotton develops oospores when grown with a very different species, and its very close affinity with the coconut strain, suggest that all strains of *faberi* might be induced to develop oospores when grown with strains of such a distinct species as *parasitica*. The formation of oospores by the *faberi* strains here reported cannot be accounted for by the theory of the heterothallism of *P. faberi* in view of the fact that they are formed in the mixtures of strains of this fungus with known homothallic strains. What the factors are that induce oospore formation in mixed cultures by *faberi* strains which do not produce them in pure cultures remains an open question. The view here put forward is that the formation of these sexual organs is related to the rate of metabolism of the thallus which is largely influenced by environment. The view is held that a normal strain of *P. faberi* is capable of both asexual and sexual reproduction; that the former is induced by a high rate of metabolism characterised by a high water content and a certain ratio of food materials ; the latter by a low rate of metabolism characterised by a low water content, a different ratio of food materials, and possibly a low temperature. The rate of metabolism will be greatly influenced by the presence or absence of a competing organism, especially when the requirements of the two

growths approximate more closely to each other. This is ultimately in accordance with the observations of Murphy (7) on *P. erythroseptica*, that a nutritional check to the vegetative growth has initiated the sexual reproductive phase.

THE OOSPORES OF P. NICOTIANAE

Some observations were also made on mixed cultures containing *P. nicotianae* Br. de Haan. This species has been known for many years as the cause of serious losses in the susceptible " Deli " tobacco in the seed-bed and field in Sumatra, and of more occasional damage to other varieties in Java. *P. nicotianae* was for many years regarded as highly specialised in host range having been definitely observed only on tobacco. Fairly recently it was found attacking castor oil plants (*Ricinus communis*) in the seed-bed in Sumatra and was successfully inoculated on tomato. During recent years it has attacked tobacco in Florida, and the culture used had been isolated by W. S. Tisdale from tobacco in that area. It was kindly sent to Prof. Ashby by Prof. W. H. Weston, Jr., of Harvard University early in 1925.

Sub-cultures on potato extract, bean, maize-meal, and quaker-oats agars developed no oospores, with the exception of a very few embedded in the surface plectenchyma on the last-named medium. The pure cultures showed a copious aerial mycelium, few sporangia, but chlamydospores in abundance. Sporangia were developed freely from fragments of young agar cultures after lying in water for a day, and discharged zoospores readily. Zoospore suspensions yielded prompt infections on the uninjured leaves of a thin-leaved tobacco plant. The spots enlarged rapidly without forming sporangia on their surfaces. Fragments from the margins of spots transferred to water yielded sporangia abundantly after one to two days. These sporangia resembled those of *P. parasitica*, the mean of fifty measurements being :—length 45·7 microns, breadth 32·5 microns, ratio 1 : 1·4. One hundred chlamydospores from a two months' old lima-bean agar culture gave a mean of 34·0 microns and a range of 21·6 to 57·6 microns.

Mixed cultures

P. nicotianae was grown in mixed culture with the same strains of *parasitica* and *faberi* used in the foregoing mixtures. In all of these cultures *P. nicotianae* was inoculated on the top half of the agar slants. In the case of the mixtures with the *faberi* strains, in some of the cultures oospores were freely produced, in others scantily, and in some not at all. The mixtures with the *parasitica* strains were more regular and tables G and H present a summary of these mixed cultures. Cultures Nos. 44

and 45 appeared to contain oospores of *P. nicotianae* alone ; culture No. 42 those of the *parasitica* strain alone, and the rest of the cultures oospores of both species. The inference may be drawn that the oospores of *P. nicotianae* have a mean of approximately 22 microns and a range of approximately from 18·0 to 25·0 microns.

All the oospores seen in the mixed cultures were very definitely of the amphigynous type. The oospores were described by Breda de Haan as of the paragynous type, but that was many years before the amphigynous form of development had been observed. Oospores do not appear to have been seen by the later investigators in the Dutch East Indies. These observations tend to indicate that the three fungi, *viz. P. nicotianae*, *P. palmivora*, and *P. faberi*, may all be strains or forms of one species.

TABLE G

nicotianae *and* parasitica *strains*

Serial No.	*nicotianae* in mixed culture with *parasitica* strain.	Medium and temp.	Age of culture in months.	Number of oospores measured.	Position on slant.	Mean in microns.	Standard error.	Range in microns.
41	I	Bean. Ice chest.	2	50	Apex.	20·46	·294	14·4—24·3
42	I	Bean. Room temp.	2	50	Middle.	17·76	·203	14·4—21·6
43	II	Bean. Ice chest.	1	50	Middle.	19·36	·236	16·2—23·4
44	II	Bean. Room temp.	2	50	Middle.	20·7	·219	18·0—23·4
45	III	Bean. Ice chest.	1½	50	Apex.	21·0	·242	18·0—23·4
46	III	Bean. Room temp.	2	50	Apex.	20·0	·227	16·8—23·4

TABLE H

Frequency arrays for nicotianae *and* parasitica *strains*

Serial Nos.	41	42	43	44	45	46	Totals.
Microns.							
Under 15	1	5	—	—	—	—	6
15—16·9	7	11	6	—	—	1	25
17—18·9	8	29	21	8	7	19	92
19—20·9	3	4	7	14	13	9	50
21—22·9	19	1	13	22	19	19	93
23—24·9	12	—	3	6	11	2	34
25—26·9	—	—	—	—	—	—	—
	50	50	50	50	50	50	300

SUMMARY

1. Three strains of *Phytophthora parasitica* Dastur have been grown in pure culture and the mean size and range of the oospores determined.

2. Three strains of *Phytophthora faberi* Maublanc have been grown in mixed cultures with each other and the mean size and range of oospores produced have been recorded.

3. The three *parasitica* strains have been grown in mixed culture with the three *faberi* strains and the sizes of the oospores produced have been recorded.

4. Evidence is obtained that each of the strains of *faberi* have developed oospores when grown in culture with homothallic *parasitica* strains.

5. It appears probable that all strains of *faberi* can be induced to develop oospores under certain conditions.

6. These findings present no support to the view that *P. faberi* is heterothallic ; direct evidence of heterothallism in the genus *Phytophthora* has not yet been recorded.

7. Mixed cultures of *parasitica* strains with *Phytophthora nicotianae* Br. de Haan have developed oospores which indicate a mean size of 22·0 microns and a range of 18·0 to 25·0 microns for the oospores of *nicotianae* ; all the oospores seen in these cultures were distinctly of the amphigynous type.

8. The theory is put forward that the development of oospores by strains or species of *Phytophthora* is due to the influence of environment on the rate of metabolism of the thallus.

REFERENCES

1. Ashby, S. F. Oospores in cultures of *Phytophthora faberi*, Kew Bull. Misc. Inf. 9, pp. 257-262, 1922.
2. Blakeslee, A. F. Sexual reproduction in the *Mucorineae*. Proc. Amer. Acad. of Arts and Science, Vol. XL, pp. 205-319, 1904.
3. Burgeff, H. Uber. Sexualitat, Variabilitat, und Verebung bei *Phycomyces nitens*. Ber. Deutsch. Bot. Gesell, 30, pp. 679-685, 1912.
4. Butler, E. J. Bud-rot of coconut, and other palms. Rept. of Proc. of the Imp. Bot. Conf., London, 1924, pp. 146 and 147.
5. Gadd, C. H. *Phytophthora faberi*, Maublanc. Ann. Roy. Bot. Gard, Peradeniya, IX, pp. 47-89, June, 1924.
6. Leonian, L. H. Physiological studies on the genus *Phytophthora*. Amer. Jour. Bot. XII, 7, July, 1925.
7. Murphy, P. A. The Morphology and cytology of the sexual organs of *P. erythroseptica*, Pethyb. Ann. Bot. XXXII, No. cxxv, pp. 115-154, Jan., 1918.

APPENDIX

Note on the stromatoid bodies found in the mixed cultures.

Stromatoid bodies were found in several of the mixed cultures and agree with those described and figured by Gadd. Two types were definitely noted, (*a*) large stromatoid bodies, and (*b*) small stromatoid bodies.

(*a*) Large stromatoid bodies. These are large compact bodies of apparently cellular structure and in all cases noted of a lighter or darker yellowish colour. These bodies bore the same relations to the oospores as described by Gadd (*loc. cit.*) The impression was that they increased in size by an increase in the number of cell units round the peripheral region of the bodies, and in number as the numbers of the oospores in the cultures increased. The cells of which these bodies are composed react as if of a granular proteid nature.

(*b*) Small stromatoid bodies. These bodies appeared to have the same structure as those figured by Gadd (*loc. cit.*, plate X, fig. 18), but no oospores were seen in close association with them. They were by no means so abundunt as the large stromatoid bodies and all those noted were hyaline. No connection was observed between these bodies and the large stromatoid bodies.

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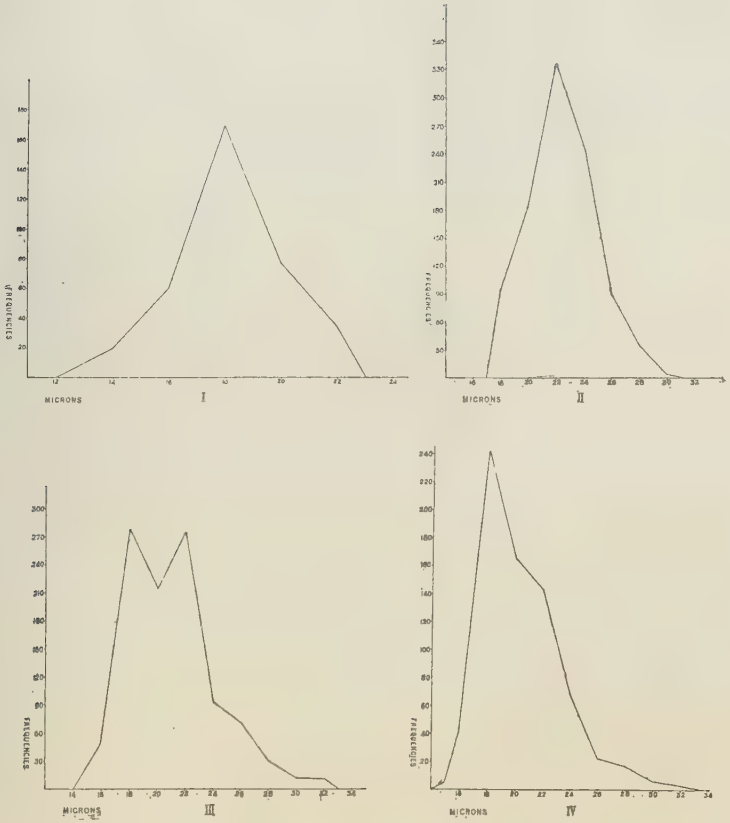

Plate XI

Graph I. *parasitica* strains in pure culture.
Total of frequencies (Table B).

Graph II. *faberi* strains in mixed culture with each other.
Total of frequencies (Table D).

Graph III. *parasitica* strains in mixed culture with the *faberi* strain from cacao. (Table F, total Nos. 10-17 and 30-40.)

Graph IV. *parasitica* strains in mixed culture with the *faberi* strain from coconut. (Table F, total Nos. 18-24).

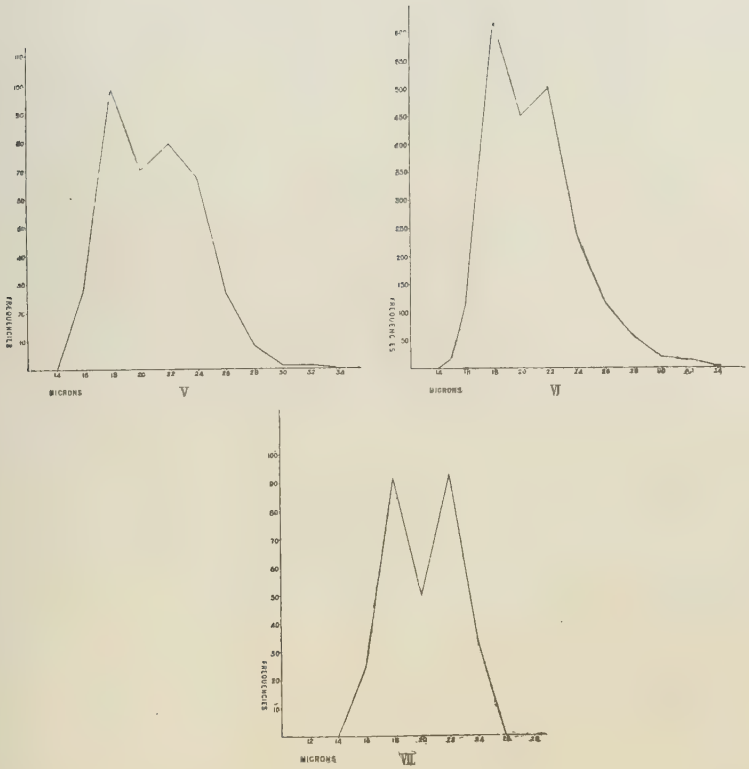

Plate XII

Graph V. *parasitica* strains in mixed culture with the *faberi* strain from cotton. (Table F, total Nos. 25-29).

Graph VI. Complete total of all the mixed cultures of *parasitica* strains with *faberi* strains. (Table F).

Graph VII. *nicotianae* in mixed culture with *parasitica* strains. (Table H).

Some investigations into conditions affecting the parasitism of Rhizoctonia solani Kühn

BY

Malcolm Park, A.R.C.S.

Assistant Mycologist, Department of Agriculture, Ceylon

INTRODUCTION

Diseases of herbaceous plants caused by *Rhizoctonia solani* have of late attracted attention in Ceylon. Gadd and Bertus (1) have recently completed investigations which have shown that, under favourable conditions, this fungus is capable of attacking a great variety of plants, particularly as seedlings. As the fungus lives in the soil it is difficult to treat affected areas satisfactorily. The experiments described below were carried out in the laboratory in order to study some of the physiological relations of host to parasite, so that practical recommendations for the control of the disease might be made from results obtained.

Various workers have studied *Rhizoctonia* diseases and have made suggestions with regard to the physiological conditions favouring the incidence of the disease. Briton-Jones (2), investigating "Sore-Shin" of cotton (due to *R. solani*) in Egypt, discussed conditions affecting the fungus in the field. He stated that increase in temperature of the soil lessened the incidence of "Sore-Shin," "not because of its direct inhibiting effect on the growth of the fungus but indirectly because of its accelerating effect on the growth of the seedling, and drying up of the upper layer of the soil, which has an inhibiting effect on the growth of the fungus." It would appear from his remarks that the more important influence is the moisture content of the surface layers of the soil. Again, in his general recommendations he emphasises the need of well-drained soil and of dry surface conditions. Gratz (3) working on wire-stem of cabbage caused by *R. solani* mentions experiments which indicate that a low temperature and a dry surface (obtained by covering the beds with a layer of sand $\frac{1}{4}$ inch thick) may reduce the incidence of the disease or delay it. Matz (4) says that plants producing abundant foliage are more liable to attack during suitable weather conditions, as the density of the

shade favours the growth of the fungus by conserving the humidity of the air.

From the writings of these and other workers it is obvious that soil-moisture and humidity of the air play an important part in the extent of damage caused by this fungus. Attention has been paid to these two conditions in the investigations discussed in this paper. The original intention was to study only the soil-moisture factor, but it was found during the course of the experiments that humidity of the atmosphere had a considerable bearing on the subject and in consequence a study was also made of that factor.

TECHNIQUE

In preliminary work to discover a suitable technique, experiments were carried out with dhal (*Cajanus indicus*) seeds grown in test-tubes containing soils of different water-content. This method was found to be unsatisfactory chiefly because of the relatively small amounts of soil used. Plugging of the test-tubes affected the humidity, and without plugs the loss by evaporation of a very little water considerably affected the percentage water-content. Cotton seeds were tried and were found to be of a more convenient size, and, as the disease of cotton due to *R. solani* is of economic importance, it was thought that results obtained would be more useful if directly applicable to such a crop. Therefore cotton seeds (Cambodia var.) were used in the experiments described below. Another point brought out by these preliminary experiments was the necessity for using an uniform soil and also, at any rate in the first instance, for the addition of water to the bottom layer of the soil rather than to the top. By doing this air-locks were obviated and a more natural form of wetted soil was obtained. Consequently the soil water was always added to the containing vessel before the dry soil.

The soil used throughout these experiments was prepared by heating garden soil in a hot air oven at 110°C. to 120°C. for about 3 hours and sifting it through a 40-mesh sieve. This gave a very fine and rather clayey soil. The heating sterilised the soil and prevented interference by other soil organisms. It was found that saturation of this soil was obtained by the addition of 35 per cent. of its weight of water. Beakers of 1 litre capacity were used and in these soil-moisture experiments water lost by evaporation was replaced each day by adding water through a glass tube ($\frac{1}{2}$ inch in diameter) which was placed in each beaker before the addition of soil. By this means water reached the surface by percolation and water-logging of the surface soil was prevented.

The beakers with their lengths of glass tubing were weighed. Soil to a depth of four inches was added to each and the weight obtained; this amounted to about 1,000 grammes. The soil was removed and water equivalent to 35 per cent. of the weight of the soil added to each beaker. The soil was then replaced and the tube in each beaker was arranged so that it stood vertically in the centre of the soil. The soil in five beakers was inoculated by placing pieces of sclerotia of *R. solani* from culture on maize-meal agar on the surface and all were covered with clock glasses. Germination of sclerotia was observed and hyphae were seen to grow over the surface of the soil. After five days the covers were removed and the required water-content of the soils was obtained by evaporation at laboratory temperature. Determination of the water-content of the soils was made by weighing. Once the correct water-content was obtained it was made up to standard each day by the addition of water. It was thought that a more equal infection of soils would be obtained by inoculating soils of equal water-content and allowing the excess water to evaporate than by inoculating soils containing different amounts of water.

After twenty days the water-content of the soils had reached the proposed quantities. Two sets of beakers of soil, one inoculated and one control, each contained 35, 30, 25, 20 and 15 per cent. water and the experiments were carried out with soils with these water-contents. It was found during these experiments that the loss of water by evaporation in one day was never equivalent to more than 2 per cent of the weight, of the soil; it was considerably less than this in the drier soils.

As has been stated above, cotton seed (Cambodia variety) was used. The seeds were de-linted by immersion in concentrated sulphuric acid for about 2 minutes, washed in several changes of water and presoaked over night. On the following day the seeds were germinated on damp blotting paper in glass boxes until the radicles had emerged $\frac{1}{4}$ to $\frac{1}{2}$ inch. At this stage they were planted.

Experiment I

Ten seeds were planted in each beaker at a standard depth of about 1 inch. By using germinated seed it was found possible to obtain a very large percentage of seedlings from the planted seed, and the error due to bad seed was thus minimised.

Psychometric readings were taken throughout the series of experiments and laboratory temperatures noted. Seeds planted in the soil inoculated with *R. solani* by means of sclerotia grew well and not a single case of positive infection was noted. This was thought to show that the infection of the soil was unsatisfactory and the experiment was closed. It was followed immediately by Experiment II which is described below.

Experiment II

When it was found that none of the cotton seedlings in the inoculated soil of Experiment I were infected, artificial inoculation with *R. solani* from a culture on maize-meal agar was made in the 5 inoculated beakers by placing small pieces of mycelium on the hypocotyls of the seedlings at soil level. All the beakers were then covered in order to aid infection. In three days all inoculated seedlings showed positive infection at the point of inoculation. At this stage all the seedlings in both control and inoculated beakers were cut into small pieces with flamed scissors and left on the surface of the soil for a week. In this time, *R. solani* grew abundantly in the inoculated beakers. After one week the remains of the seedlings were mulched into the surface of the soils of their respective beakers. It was considered that this material would supply the food necessary to keep *R. solani* in an active state and thus ensure that any lack of infection would be due, not to the absence of the parasite, but to other causes.

Seeds were prepared and germinated as before and were planted out in the beakers, ten seeds in each. The results of this planting are shown in Table I.

TABLE I

No. of beaker.	Water-content of soil.	No. of seeds.	Treatment.	After 5 days.		After 10 days.		Total number of diseased seedlings.
				No. of seedlings visible.	Seedlings diseased (visible).	No. of seedlings visible.	Seedlings diseased (visible).	
1	35 %	10	C	9	—	9	—	0
2	35 %	10	I	2	1	3	3	10
3	30 %	10	C	10	—	10	—	0
4	30 %	10	I	5	—	5	4	9
5	25 %	10	C	10	—	10	—	0
6	25 %	10	I	10	—	10	—	0
7	20 %	10	C	8	—	8	—	0
8	20 %	10	I	4	—	4	2	8
9	15 %	10	C	10	—	10	—	0
10	15 %	10	I	9	—	9	—	0

C = Control. I = Inoculated.

During the period of experiment the average humidity, as measured by wet and dry bulb thermometers, was 75·0 per cent. Readings were taken three times a day, at 9·30 a.m., noon and 4·30 p.m. The average temperature at 9·30 a.m. was 78·0° F. and the average maximum and

minimum temperatures 82·1°F. and 71·9°F. respectively. It will be seen from these figures that the temperature was fairly constant, while the humidity was high.

The most noticeable point in this experiment was the fact that failures of seeds to develop into seedlings were more numerous in inoculated pots Nos. 2, 4 and 8 than in the others. At the conclusion of the experiment seeds which had failed to develop were dug up. It was found that in the inoculated soils they had been attacked by the fungus before reaching the surface, except in the case of one seedling in beaker No. 10 which had been injured in planting. The two seeds which failed to develop in control beaker No. 7 had likewise been injured in planting. Bacterial contamination, probably due to bad seed, had killed one seedling in beaker No. 1 below the surface of the soil. The last column in table I gives the total number of seedlings killed by *R. solani* in each beaker. It was noticed also that the appearance of the seedlings showed a marked grading through the range. Those in the soil containing 35 per cent. water were not very robust and their weakness was attributed to the tendency to water-logging of soil with this water-content. The seedlings in the soils containing 30, 25 and 20 per cent. water were well developed, more particularly in the soil containing 25 per cent. water. The seedlings in the soil containing 15 per cent. water were poorly developed and obviously suffered from shortage of water.

No plants were affected in the soils containing respectively 25 and 15 per cent. of water. In the former case the absence of infection may have been due either to the fact that the fungus was not present in an active state or that the seedlings resisted infection. Seeing that seedlings in soil containing 20 per cent. water under similar conditions were heavily infected, it seems improbable that the water relation in the soil affected the fungus. All pots were treated similarly and *Rhizoctonia* was presumably present in the soil. It is difficult to understand why the fungus failed to attack the seedlings. Conditions may have been so favourable to growth that they were able to resist attack, but, in view of results obtained in later experiments, it seems more likely that the fungus was not in an active condition or that the soil was not thoroughly infected.

In the case of soil containing only 15 per cent. water, the surface soil became dry and the obvious explanation for the absence of infection is that insufficient water was present in the surface soil for active parasitism to take place.

The data obtained from this experiment, although indicating that the water-content of soil might have some influence on the parasitism of *R. solani*, were not conclusive. It was therefore decided to repeat the experiment.

Experiment III

The beakers from the previous experiment were covered with clock glasses and all the healthy seedlings in infected soil were re-infected with *R. solani* from culture. The seedlings in beakers Nos, 1, 3, 5, 7, 9 were all healthy and were cut up and mulched into the surface soil. Those in the other beakers all became heavily infected and were treated similarly. After 4 days a new set of seeds was prepared in a manner similar to the former. Then the radicles had emerged $\frac{1}{4}$-$\frac{1}{2}$ inch, the seedlings were planted, ten in each beaker, at a uniform depth. The water-contents of the beakers were made up to standard by the addition of water via the central tube to counteract loss by evaporation.

The results of the planting are summarized in Table II.

TABLE II

Beaker No.	Water-content of soil.	No. of seeds.	Treatment of soil.	After 5 days.		After 10 days.		After 15 days.		After 20 days.		Total number of diseased seedlings.
				Seedling visible.	No. diseased (visible).	Seedling visible.	No. diseased (visible).	Seedling visible.	No. diseased (visible).	Seedling visible.	No. diseased (visible).	
1	35 %	10	C	10	—	10	—	10	—	10	—	0
2	35 %	10	I	4	—	4	1	4	2	4	3	9
3	30 %	10	C	10	—	10*	—	10*	—	10*	—	0
4	30 %	10	I	10	—	10*	—	10*	3	10*	10	10
5	25 %	10	C	10	—	10	—	10	—	10	—	0
6	25 %	10	I	10	—	10	—	10	—	10	—	0
7	20 %	10	C	9	—	9*	—	9*	—	9*	—	0
8	20 %	10	I	9	—	9*	—	9*	7	9*	9	9
9	15 %	10	C	9	—	9	—	9	—	9	—	0
10	15 %	10	I	3	—	3	—	4	—	6	—	0

* Special treatment after 10 days as described below.
C = Control. I = Inoculated.

In discussing these results it will be better to consider them in two sections:—the results up to ten days after the beginning of the experiment and those after that time. It will be seen when considering the former section that of the seedlings which developed to the extent of being visible above the soil only one, in the wettest inoculated soil, was infected. The fact that only four seedlings developed in this pot out of the ten germinated seeds planted points to the possibility that the others were attacked by the fungus while still in the soil, and this was confirmed by examination at the conclusion of the experiment. In beaker No. 10 (containing 15 per cent. water) only three seedlings developed in 10 days,

whereas in beaker No. 9, 9 seedlings developed in the same time. All the seedlings which appeared in the soil of the former water content were obviously suffering from an insufficient water supply, and the fact that up to 20 days after planting new seedlings developed in pot No. 10 indicates that the absence of seedlings was due to lack of sufficient water rather than to infection by the fungus in the soil.

Apart from this, it was obvious that the results at the end of 10 days after planting were different from those obtained in the previous experiment. The only explanation of this difference was that the humidity of the air affected the results. Whereas the earlier experiment had been done in wet weather with an average humidity of 75 per cent., the conditions during the period of the experiment under review were different. The weather was fairly cool and dry and the average humidity was as low as 52·2 per cent. The average maximum and minimum temperatures were 83·0° F. and 71·1° F. respectively with an average temperature at 9·30 a.m. of 74·4° F. These temperatures approximated quite closely to those of the previous experiment and therefore differences could not be attributed to variation of the temperature factor. It was apparent that either the low humidity prevailing during the experiment had some bearing on the absence of infection or that the fungus was not actively present. In order to settle the latter question it was decided to cover two of the pairs of beakers and thereby increase the humidity. Beakers Nos. 3 and 4 containing soil with 30 per cent. water and Nos. 7 and 8 with 20 per cent. water were covered with bell-jars. The results are to be found in Table II. It is seen that in both of the covered beakers containing infected soil 100 per cent. positive infections resulted without any further inoculation with *Rhizoctonia*, whereas the controls under similar conditions remained healthy. The other beakers were left exposed to the atmospheric conditions during this time, and it will be seen from Table II that, whereas infection proceeded in the inoculated soil containing 35 per cent. water until one seedling only remained healthy, there was no infection in the inoculated soils containing either 25 or 15 per cent. water.

These results show that humidity of the air plays a part in the question of infection by *Rhizoctonia* as important as, if not more important than, that played by soil-moisture. It was obvious that, in order to throw some further light on the conditions affecting the infection of seedlings by *Rhizoctonia*, a further series of experiments with controlled humidity was necessary. These are described below.

CONSTANT HUMIDITY TRIALS

The first question which arose in connection with these experiments was that of obtaining a series of atmospheres of constant humidity

with the rather limited apparatus available. It was necessary that the method used should give readily a range of humidities which should not vary greatly and which could easily be standardised. It was realised very soon that the fact that the soil contained water and that the seedlings transpired at an early stage of development would lead to errors.

It was decided that a suitable method of obtaining atmospheres of constant humidity would be by the use of sulphuric acid of varying concentrations. Regnault (5) gives a table which shows the equilibrium pressure of aqueous vapour above dilute sulphuric acid, expressed as a percentage of the maximum pressure above pure water at the same temperature ; this is given in Table III.

TABLE III

	Grammes H_2SO_4 in 100 grammes mixture								
To C	84·48	73·13	64·47	57·65	52·13	43·75	37·69	33·10	24·26
10	1·25	5·46	13·09	20·57	33·05	48·73	63·03	70·05	84·15
20	0·89	4·90	12·89	21·44	33·30	48·84	62·28	70·82	83·27
30	0·71	4·72	12·87	22·23	33·87	49·44	62·11	70·22	82·78

It will be observed that the figures do not vary to any considerable extent with the temperature up to 30°C. An experiment was set up to determine whether, under the proposed experimental conditions, these figures could be adopted.

The apparatus was as in figure I. It consisted of a bell-jar (A)on a sheet of glass (B), the junction being sealed with plasticine (C). Sulphuric acid and wet and dry bulb thermometers (F) were placed under the bell-jar. The acid, of which 350 c.c was used at each determination, was placed in the lower part of a glass box (D); the water container for the wet bulb thermometer was a glass spirit lamp (E), the wick of which was used to keep the bulb of the thermometer wet. This form

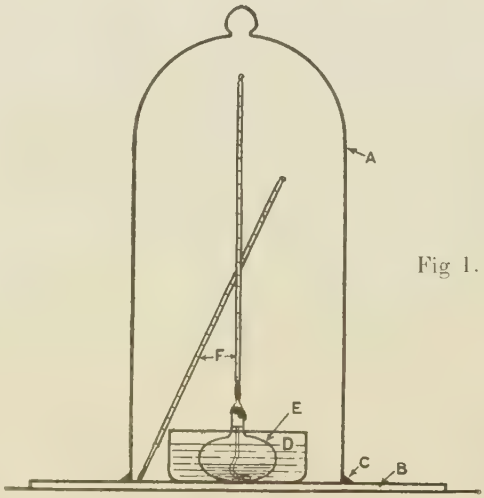

Fig 1.

of container prevented error from undue evaporation of the water. The psychometric thermometers were unfortunately too large to be used in this apparatus and smaller thermometers graduated in 1 C. (F) had to be used. The personal error in reading these was minimised by taking the average of a number of readings. The concentration of sulphuric acid was determined by means of a hydrometer before and after the series of readings and the mean concentration of acid considered to give the mean humidity. Domke's (6) tables for the density and specific gravity and hydrometer corrections for sulphuric acid were used throughout. Readings were taken four or five times a day over a period of three to four days, and it was found that the humidities calculated from these readings did not vary by more than 2 per cent. with one concentration of acid. The results obtained from 10 such humidity trials are given in Text fig. 2.

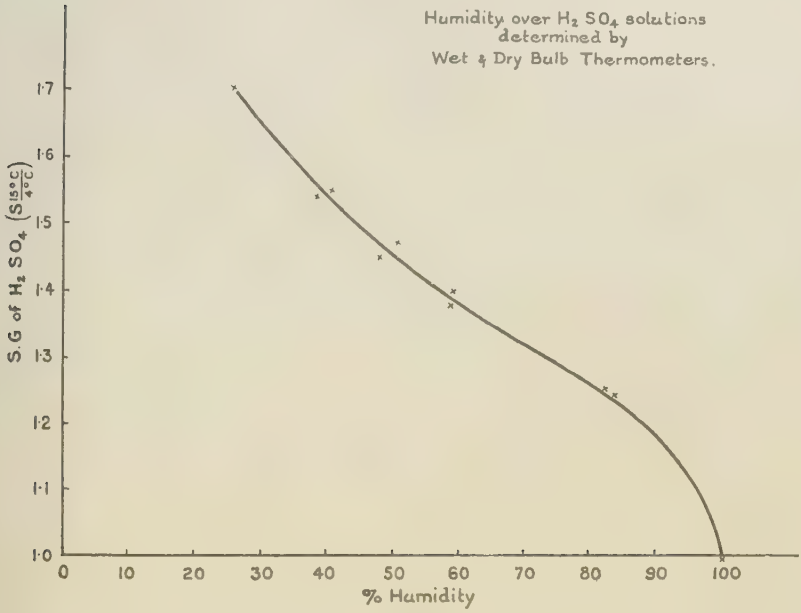

Fig. 2

Figure 2 shows that the results give a fair curve. Sources of error due to inaccuracies of the thermometers, hydrometers, etc., would account for the non-coincidence of the points with the curve.

These results differ considerably from those given in Regnault's table. As they were obtained under conditions very similar to those which would hold for the main series of experiments these results were preferred to those of Regnault. Consequently the humidities of the atmospheres in the series about to be described were determined by the method given above, but, nevertheless, in the results tabulated later both sets of figures are given.

Experiment IV

This experiment was carried out to determine if, in soils of the same water-content, humidity of the atmosphere would have any effect on the rate and extent of infection of cotton seedlings by *Rhizoctonia solani*. The soil used in this experiment was similar to that used in the previous experiments and was treated in the same way : cotton seed of the same variety was used. Cigarette tins were used as containers. These, for the sake of convenience, were divided into groups of four and each group was brought to a standard weight by the addition of sheet tin.

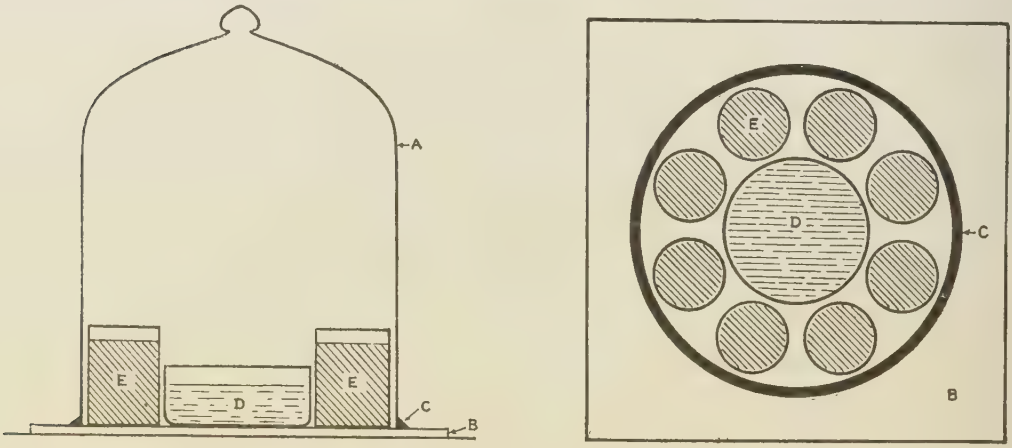

Fig. 3

62·5 grammes of water and 250 grammes of soil were added to each tin. The water-content of the soil (25 per cent.) was standard throughout the experiment. Cotton seeds were germinated as before and planted five in each tin. On the development of seedlings in a moist atmosphere, one-half of the number of prepared tins was inoculated with *Rhizoctonia solani* from a culture on maize-meal agar. All the inoculated plants

became heavily infected in 4 days. Every seedling, both control and inoculated, was cut up and mulched into the surface of the soil, as had been done in the previous experiments. After a fortnight's interval germinated seeds were planted, again five per tin, for the experiment proper. In each series, eight of these tins were used, four containing inoculated soil and four containing uninoculated soil as controls. Thus in each atmosphere of constant humidity there were twenty seeds in inoculated soil and twenty seeds as controls. The tins were arranged under bell-jars on sheets of glass as in Text fig. 3.

By preparing sulphuric acid of different concentrations five series were set up with atmospheres of approximately 40, 50, 60, 85 and 100 per cent. humidity respectively. The humidity figure for each atmosphere series was obtained by setting up a trial experiment, as described above, with a quantity of the same acid as was used for the series. Errors due to hydrometers and impurities of the acid were minimised by this means. 350 c.c. of acid were used under each bell-jar. Seeds were planted, and the experiment set up in one day. Bell-jars were removed on alternate days, the water-content of the soils brought up to 25 per cent. by addition of water, and the acids brought to their original specific gravity by the addition of concentrated sulphuric acid. It had been found by previous experiment that the humidity change due to the absorption of water by, and the consequent dilution of, the acid was in the case of the strongest acid less than 5 per cent. in two days.

The results of the experiment are summarized in Table IV.

TABLE IV

Series No.	Tin No.	Treatment.	Humidity determined by trial.	Relative Humidity as calculated from Regnault's Table.	After 2 days.		After 3 days.		After 4 days.		After 6 days.		After 8 days.	
					No. of seedlings.	No. of diseased.	No. of seedlings.	No. of diseased.	No. of seedlings.	No. of diseased.	No. of seedlings.	No. of diseased.	No. of seedlings.	No. of diseased.
I	1	Control	100%	100%	5	—	5	—	5	—	5	—	5	—
	2				5	—	5	—	5	—	5	—	5	-
	3				5	—	5	—	5	—	5	—	5	—
	4				5	—	5	—	5	—	5	—	5	-
	Total				20	—	20	—	20	—	20	—	20	—
	5	Inoculated	100%	100%	5	—	5	2	5	2	5	3	5	5
	6				3	—	4	1	4	2	4	4	4	4
	7				4	—	4	—	4	—	4	2	4	4
	8				4	—	5	—	5*	—	—	—	—	—
					16	—	18	3	18	4	13	9	13	13

* Tin No. 8 was discarded after four days.

Table IV—(*Contd.*)

Series No.	Tin No.	Treatment.	Humidity determined by trial.	Relative Humidity as calculated from Regnault's Table	After 2 days.		After 3 days.		After 4 days.		After 6 days.		After 8 days.	
					No. of seedlings.	No. of diseased.	No. of seedlings.	No. of diseased.	No. of seedlings.	No. of diseased.	No. of seedlings	No. of diseased.	No. of seedlings.	No. of diseased.
II	9	Control	84·7%	74%	5	—	5	—	5	—	5	—	5	—
	10				2	—	5	—	5	—	5	—	5	—
	11				3	—	4	—	4	—	4	—	4	—
	12				3	—	4	—	4	—	4	—	4	—
					13	—	18	—	18	—	18	—	18	—
	13	Inoculated	84·7%	74%	1	—	4	—	5	2	5	3	5	5
	14				1	—	4	1	4	3	4	4	4	4
	15				3	—	5	2	5	3	5	5	5	4
	16				5	—	5	—	5	1	5	3	5	5
					10	—	18	3	19	9	19	15	19	18
III	17	Control	59·6%	45%	4	—	5	—	5	—	5	—	5	—
	18				5	—	5	—	5	—	5	—	5	—
	19				4	—	5	—	5	—	5	—	5	—
	20				4	—	5	—	5	—	5	—	5	—
					17	—	20	—	20	—	20	—	20	—
	21	Inoculated	59·6%	45%	2	—	3	—	4	2	4	3	4	3
	22				4	—	4	1	4	2	4	2	4	2
	23				4	—	4	—	4	—	4	2	4	4
	24				5	—	5	—	5	2	5	5	5	5
					15	—	16	1	17	6	17	12	17	14
IV	25	Control	48·8%	30%	5	—	5	—	5	—	5	—	5	—
	26				5	—	5	—	5	—	5	—	5	—
	27				5	—	5	—	5	—	5	—	5	—
	28				5	—	5	—	5	—	5	—	5	—
					20	—	20	—	20	—	20	—	20	—
	29	Inoculated	48·8%	30%	5	—	5	—	5	—	5	—	5	1
	30				4	—	4	—	4	1	4	1	4	2
	31				5	—	5	1	5	2	5	2	5	3
	32				3	—	4	—	4	—	4	2	4	3
					17	—	18	1	18	3	18	5	18	9
V	33	Control	41·1%	14%	3	—	4	—	5	—	5	—	5	—
	34				3	—	4	—	4	—	4	—	4	—
	35				5	—	5	—	5	—	5	—	5	—
	36				4	—	4	—	5	—	5	—	5	—
					15	—	17	—	19	—	19	—	19	—
	37	Inoculated	41·1%	14%	4	—	4	—	5	—	5	1	5	1
	38				4	—	4	—	4	—	4	—	4	—
	39				1	—	2	—	4	—	4	2	4	2
	40				3	—	4	—	4	—	4	1	4	3
					12	—	14	—	17	—	17	4	17	6

Owing to accidental damage from acid one of the tins containing inoculated soil was discarded after four days.

In no case were any of the control seedlings diseased. In inoculated soil, 100, 94·8, 84·4, 50 and 28·4 per cent. of the seedlings were attacked in atmospheres of 100, 84·7, 54·6, 48·8 and 41·1 per cent. humidity respectively. It will be seen that there is a distinct diminution of infection with the decrease of humidity. Not only was the infection in the most humid series greatest in point of number of seedlings attacked, but also greater in extent on each seedling. In the most humid atmospheres whole plants became infected in a short time and the fungus developed a copious aerial growth of mycellium. The extent of attack showed a marked gradation through the series until in the driest atmosphere the infection was localised to a small discoloured area at soil level which did not in all cases kill the seedlings. The results obtained in this experiment show that, in a soil of constant water-content, the extent of infection of cotton seedlings in soil inoculated with *Rhizoctonia solani* varies directly with the humidity of the atmosphere.

GENERAL DISCUSSION

In the second experiment detailed above it was found that, in an atmosphere of high average humidity, seedlings in soils containing 35, 30 and 20 per cent. water and inoculated with *R. solani* became infected very heavily. Inoculated soils containing 25 and 15 per cent. water showed no infection. The fact that all the seedlings in inoculated soil containing 15 per cent. water were free from disease is explained by the dryness of the surface soil. The absence of infection in soil containing so little water can have no economic importance since the seedlings which grew were poor and weakly and would not have developed further without an increased water supply. The soil contained insufficient water for the fungus to be actively parasitic and, at the same time, contained too little for the seedlings to mature normally.

In the case of the inoculated soil of 25 per cent. water-content in which 100 per cent. healthy seedlings developed, this explanation cannot hold since, in a drier soil (with 20 per cent. water), under the same conditions, 80 per cent. of the seedlings were diseased either above or below the surface of the soil. Again, in Experiment IV, in which the soil used throughout contained 25 per cent. water, there was not a single series in which infection to a greater or less extent did not occur. It must be assumed, therefore, that the inoculation of the soil in this case had been unsuccessful and that the fungus was not present in an active condition. Neglecting this sample, it may be said that, when the soils tested contained such quantities of water that robust seedlings developed,

considerable infection took place under the conditions of the experiment, *i.e.* in a humid atmosphere.

Experiment III appears at first sight to have given results which are contradictory to those obtained from Experiment IV. In atmospheres which were drier than that which prevailed during Experiment III, a considerable infection of seedlings occurred in the later experiment. The absence of infection cannot be attributed to the absence of the fungus from the soil, since, after humid conditions were introduced, all the seedlings in the inoculated soils developed the disease without further inoculation. There is, however, a possible explanation. It will be remembered that in Experiments II and III the amount of soil used in each of the series was about 1,000 grammes. The depth of the soil was 4 inches. Water, in the first instance, was placed in the beakers before the addition of the dry soil. All subsequent addition of water, in order to replace that lost by evaporation, was made *via* the glass tubes which had been placed in the soil. Thus water was always introduced to the soil from the bottom and never from the surface. In an atmosphere of low humidity this method would tend to produce an uneven distribution of water in the soil and the surface layers would contain considerably less water than the lower layers of the soil. The depth of soil in Experiment IV was only $2\frac{1}{2}$ inches and although water in the first instance was placed in the tins before the soil, it was found impracticable to make subsequent additions otherwise than to the surface soil. These factors tended to make the water distribution more equal in the latter experiment.

In Experiment III the surface soil in a comparatively dry atmosphere was dry and therefore the results obtained are not necessarily contradictory to those obtained in the other experiments. The soils in this experiment were similar to soil as it would be in a spell of dry weather in nature and from this it may be concluded that although the average water-content of soil may be relatively high, in a period of dry weather or in a period in which the humidity of the atmosphere is relatively low, infection of seedlings by *R. solani* present in soil would be slight. This conclusion and the results from the humidity experiment indicate that, if extremes of soil-moisture are excluded, the humidity of the air immediately above the soil plays a more important part in governing the parasitism of *R. solani* than does the average water-content of the soil. In nature, however, except in irrigated soils, the two factors are usually linked together.

PRACTICAL RECOMMENDATIONS

Recommendations for the control of diseases caused by *R. solani* based on the above experiments are such as will tend to reduce the humidity of the air in the plots. Shade in nurseries in which seedlings

liable to the disease are grown should be reduced to a minimum. Plants should be spaced as widely as is practicable in order to allow free passage of air between the plants. The position of a nursery should be chosen with the object of avoiding humid situations. Soil should be well drained so that the surface soil keeps as dry as possible without, of course, having a detrimental effect on the development of the plants. It has been seen in the above experiments that soils containing too much water not only favour the spread of the disease in inoculated soils but also produce inferior plants in disease-free soils.

The results of the experiments, however, show that where soil is infected with *R. solani* it is impossible to ensure freedom from the disease by altering conditions of humidity and soil moisture in the range in which plants can successfully be grown, under field conditions.

SUMMARY

Experiments (with cotton seedlings) are described above in which an attempt has been made to determine the effect on the parasitism of *Rhizoctonia solani* in inoculated soils of 1. varying soil-moisture in air during a humid period, 2. varying soil-moisture in air during a dry period, and 3. standard soil-moisture in atmospheres of varying humidity.

It has been found that, in the range of soil-moisture necessary for the successful development of cotton seedlings, a variation of water-content of the soils has little or no effect on the extent of infection of the seedlings. On the other hand, variations of the humidity of the atmosphere above the soil have an effect and results obtained indicate that infection increases with an increase of humidity.

Recommendations are made for the practical application of the results obtained.

REFERENCES

1. Gadd, C. H. and Bertus, L. S. *Corticium vagum* B. and C., the cause of a disease of *Vigna oligosperma* and other plants in Ceylon. Ann. R. Bot. Gdns. Peradeniya. (in the press).

2. Briton-Jones, H. R. Mycological Work in Egypt during the years 1920-1922. Bull. No. 49. Ministry of Agric. Egypt, 1925, pp. 1-61.

3. Gratz, L. O. Wire-Stem of Cabbage. Cornell Agric. Exp. Stat. Mem. 85. 1925 (abstract in Rev. App. Myc. IV. 9. 1925 pp. 518-519.)

4. Matz, J. The Rhizoctonias of Porto Rico. Journ. Dept. Agric. Porto Rico, V. 1. 1921 (abstract in Rev. App. Myc. I.8.1922, pp. 273-275).

5. Regnault. Relative humidity over sulphuric acid solutions. The Chemists' Year Book, 1925, p. 180.

6. Domke, J. Wiss. Abh. der K. Normal-Eichungs-Kommission, 1904, Vol. V. (also Chemists' Year Book, 1925, pp. 97-99).

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A Fusarium disease of Dadap (Erythrina lithosperma)

BY

Malcolm Park, A.R.C.S.

Assistant Mycologist, Department of Agriculture, Ceylon

WITH ONE PLATE

Specimens of a disease of Dadap were received from an estate in the Badulla district early in 1924, and similar cases have more recently been noted from an adjoining estate. From both estates it was reported that a number of trees were affected. Other cases of the disease have been received from other up-country estates, but on these the attack was confined to one or two trees only. The outbreak of the disease was associated with a spell of wet weather.

The area in which the disease occurred on the first-mentioned estate was in an exposed situation. The disease was first noticed when a number of trees failed to recover after lopping. It was then found that the lopped branches were dying back.

SYMPTOMS

The die-back may occur on trees before or after lopping, but more commonly the latter. Blisters up to 2 cm. long and 1 mm. in height appear on the cortex of branches. These are at first green-brown to olive in colour and have a water-soaked appearance. As the disease advances they dry out and become characteristic sunken areas of dead cortex, brown in colour. The cortex is shrivelled and easily separated from the wood. Developing blisters may fuse and cause a complete ringing of the stem with the result that the portion of the branch above dies off. In the case of lopped trees the die-back starts from the cut ends and proceeds more or less uniformly down the branch. The lenticels of the area affected develop pinkish pustules which are spores of a species of *Fusarium*. The typical blister-like appearance of affected

cortex is also apparent. As the die-back proceeds any young shoots which have developed previously from the newly affected area turn brown and eventually drop off. Cases have been observed of the die-back advancing down one side of the stem only. The demarcation of diseased and healthy tissue is clear, the edge of the affected cortex being somewhat raised, and darker in colour, and with a water-soaked appearance. An advanced case of an affected stem shows the brown shrivelled cortex above with a dark-brown edge adjacent to the freshly infected green cortex. Pustules of spores extrude from most of the lenticels of the diseased portions of the stem. The disease is most active in dull wet weather, and dry weather checks the spread and advance of the disease.

In early cases of attack the wood is healthy and only the tissue outside the cambium is affected. In advanced cases, however, the wood becomes discoloured and rots. This rot appears to be due to saprophytic organisms.

INOCULATION EXPERIMENTS

Portions of diseased Dadap stem obtained from an estate in the Badulla district were placed in a moist atmosphere in glass boxes. Examinations of these after a short time gave three fungi of which single spore cultures were made on nutrient agar. The fungi were a *Phoma*, and two species of *Fusarium*, one of which was present almost entirely in the microconidial stage.

The first inoculation experiment was carried out with these three fungi to determine which was pathogenic. Dadap cuttings were established and inoculations made on the stems of young shoots. The stems were sterilised by wiping with corrosive sublimate solution and washing with sterile distilled water. The inoculum used was a suspension of the spores of the fungi taken from cultures on maize-meal agar (twelve days old) in sterile distilled water. In the case of wounded inoculations the surface of the cortex was scratched with a sterile needle. The points of inoculation were covered with cotton wool wetted with sterile water and bound with paraffined tape, in order to prevent them from drying out. Two inoculations were made with each fungus, one wounded and one unwounded and two were treated similarly as a control.

The only inoculations which gave positive results were those made from culture of the second *Fusarium* strain, which was at first distinguished by the abundance of microconidia. In this case the wounded

stem showed typical symptoms after 4 days and the unwounded after 10 days.

The results are summarized in Table 1.

TABLE I

Inoculation No.	Fungus.	Treatment.	Observations.
1.	*Phoma*	Wounded.	Negative after 14 days.
2.	*Phoma*	Unwounded.	do.
3.	*Fusarium* 1	Wounded.	do.
4.	*Fusarium* 1	Unwounded.	do.
5.	*Fusarium* 2	Wounded.	Positive after 4 days—typical symptoms : lesion at point of inoculation.
6.	*Fusarium* 2	Unwounded.	Positive after 10 days, similar to above.
7.	Control	Wounded.	Negative.
8.	Control	Unwounded.	Negative.

Fusarium was re-isolated in pure culture from the stems which showed positive symptoms.

Although the number of inoculations made in the above experiment was not sufficient to conclude definitely that the strain of *Fusarium* No. 2 was the pathogen, it was sufficiently conclusive for the other two fungi to be discarded, and thenceforward work was only carried out with *Fusarium* No. 2.

Owing to the pressure of other work, it was found impossible to attempt to confirm the above by further inoculations for three months. Inoculations then made were unsuccessful, the fungus apparently having lost virulence in culture. Fresh diseased material was obtained and the same fungus again isolated. Single spore cultures on nutrient agar were prepared and inoculations made on the green stem, wounded and unwounded, and on the cut ends of lopped branches. The technique for the stem inoculations was as before. In the case of the lopped branches, branches $\frac{1}{2}$-$\frac{3}{4}$ inch in diameter were chosen and an area sterilised as before. The branches were cut off with a flamed knife at the place sterilised. Inoculum, consisting of a suspension of spores in sterile distilled water, was placed on the cut end together with a small piece

of sterile wet cotton wool to keep the point of inoculation moist, and the whole covered with a large test-tube, the lower end of which was plugged round with cotton wool. As controls, uninoculated stems and cut ends of branches treated as above, but with the inoculum replaced by sterile water, were used.

The paraffined tape was removed from the inoculated stems after 10 days, and it was found that all the five wounded controls were healthy. Of the six inoculated stems (unwounded) only one showed any sign of positive infection, there being a small discoloured patch of cortex $\frac{1}{4}$ inch in diameter at the point of inoculation. This failed to spread after removal of the tape, and dried out leaving a small brown sunken area on the stem.

Of the six inoculated stems (wounded) all showed positive infection. In the extreme case a discolouration of the whole of the surface of the stem was observed, extending 2-3 inches up and down the stem. The stem broke at this point after the removal of the tape. The extent of the disco'oured area on the least affected branch was 1 inch long by $\frac{1}{2}$ inch wide. When the tapes were removed three branches broke at the point of inoculation. The discoloured patches on the others failed to extend and dried out leaving lesions of varying extent. This drying out may be attributed to the dry weather prevailing at the time of the experiment.

Different symptoms were obtained from inoculations on the cut end of lopped branches. In each case the fungus developed strongly on the cut surface and a die-back of the inoculated branch occurred. Water-soaked blister-like swellings of the cortex, similar to those which appear on diseased branches in nature, developed on each of the inoculated stems. Pinkish pustules of spores extruded from the lenticels. The die-back spread rapidly so long as the tubes were left on the stems, preserving a moist atmosphere. On removing the tubes and exposing the inoculated stems to the dry conditions prevailing, the die-back ceased and drying out of the affected cortex took place, leaving the stems in a condition typical of dried diseased stems under natural conditions. *Fusarium* was obtained in pure culture from the extruding pustules of spores and was of the same species as that used for the inoculations. Of the six controls for the cut-end inoculation one was contaminated by bacteria and was discarded after 3 days, but the others remained healthy and failed to die back.

Results are summarized in the Table II.

TABLE II

Diseased material received 28.11.24. Pure cultures of *Fusarium* obtained same day : single spore isolations 2.12.24. Inoculations made 12.12.24.

Treatment.	No. of Inoculations.	Observations after 3 days.	Observations after 10 days.	Observations after 24 days.
1. Wounded control	5	—	All negative.	All negative.
2. Inoculated stem Unwounded.	6	—	1 with discoloured patch, 5-6 mm. diam.	5 negative 1 positive (slight.)
3. Inoculated stem Wounded.	6	—	6 positive.	6 positive (3 cases branch broken; 3 cases wound dried out and callus forming).
4. Inoculations on cut end of pruned branch.	6	Hyphae developed vigorously on all cut ends.	6 positive.	6 positive.
5. Controls : cut ends of lopped branches.	6	1 Bacterial (discarded) 5 negative.	5 negative.	5 negative.

From these results it is seen that the *Fusarium* isolated can cause a die-back and that it probably enters the host through a wound. The results suggest that entry is usually obtained through the cut-ends of branches of lopped trees, and also that atmospheric conditions must be favourable to the pathogen before it can develop strongly and that damp conditions are necessary for a serious outbreak of the disease.

THE FUNGUS

The external development of the fungus on the diseased Dadap is very scanty and is confined to the pustules of spores which extrude from the lenticels. At first these spores are mainly microconidia, followed later by macroconidia. The pustules are pinkish in colour. Pure cultures are obtained quite readily. The following notes are made on cultures originating in a single spore isolation, sub-cultures of which provided material for the successful inoculation experiment.

Studies of the fungus were made on several media and the characteristics of colour and aerial morphology compared. On no medium has a perfect stage been found, nor have sclerotia been observed. Chlamydospores are formed freely in old cultures on all media. Measurements both of microconidia and macroconidia were made of spores from cultures on various media at different ages ; in each case 100 spores were measured and the mean obtained.

No specific name has been applied to the fungus, but the following data are recorded for the purposes of identification. It is realised that the characters of the fungus do vary in culture, and that the dimensions of the spores vary with conditions and with the substratum on which the fungus is grown, but a study of the lengths of spores by biometric means has given certain comparable results which are discussed below.

The hyphae of the fungus, as found in culture, are fine, regular, septate, and hyaline when examined microscopically, and are 1-2μ in diameter. They branch freely and anastomoses have been observed, particularly of the germ-tubes of conidia in water and in old cultures. Aerial mycelium develops fairly strongly at first in culture, and large numbers of microconidia are formed in heads, usually terminally on rather short lateral hyphae. The mycelium at this stage is white in colour and later becomes dirty white. As the culture becomes older the aerial mycelium is less evident and in strong cultures producing sporodochia abundantly, little or no aerial mycelium is seen. Submerged hyphae are rather broader than the others and are sometimes irregularly swollen up to 5μ in diameter.

The microconidia (0-septate spores) are extremely variable in shape and size and are borne in typical *Cephalosporium* heads. They are the first spores to form and are found in abundance in cultures 3-4 days old. As mentioned above, they are formed terminally on rather short single conidiophores, which arise as lateral branches of the main hyphae and the heads are found singly and not in whorls or clusters. The majority of these conidia are more or less elliptical in shape, but spores may be pear-shaped, allantoid, or sub-fusoid. Examples are shown in Plate XIII fig. 2. They range from 5-11μ × 2-4μ in size, and the mean is 7·2μ × 3·1μ.

The macroconidia are borne in sporodochia which are up to 3 × 1.5mm. by 1 mm. high, in size. The sporodochia do not vary much in colour on different culture media. They are honey-brown, amber-brown, or yellow-brown in colour and when in "high culture" and supplied with plenty of moisture are smooth and shining rather like certain bacterial colonies. As the culture becomes old and dry the surface of the sporodochia becomes dull and the colour darkens somewhat. As the cultures age chlamydospores are formed by the conidia; then the sporodochia become discoloured and a dark-green tinge is observed, though the colour of the sporodochia is never completely changed. This change of colour begins to take place as chlamydospores are formed and it is assumed to be due to the formation of these. Chlamydospores are slightly darker when examined microscopically and no green colour is seen.

The sporophores of the macroconidia are verticillately branched, the branching usually being into threes (Plate XIII, fig. 3). Spores are produced terminally and in succession, but the spores drop off at once and do not, as in the case of microconidia, form a head.

The macroconidia are fairly uniform in shape throughout the range on the culture media examined, being straight or slightly curved with falcate tips (Plate XIII, fig. 1). The diameter of the spore is nearly uniform except at the tips. Spores are mostly 5-septate and the arithmetical mean of a number of mature spores on different culture media averages $54{\cdot}2 \times 4{\cdot}7\mu$.

Chlamydospores may be formed either on the submerged or on the aerial mycelium or from macroconidia, and are found in older cultures. They are smooth, thick-walled, intercalated or terminal on the mycelium, or produced before or after germination of conidia. They are either formed singly or in chains of two or three and occasionally four (Plate XIII, figs. 4-5). Singly, they are 8-10μ in diameter. Microscopically they appear to be slightly darker in colour than the other spores, but this may be due to the thickness of the wall. When produced in a conidium the contents of all the cells pass into any one cell which becomes swollen and thick-walled (Plate XIII, fig. 6). Sometimes one or more germ-tubes from one conidium anastomose with another and all the contents of both conidia produce one or two chlamydospores (Plate XIII, fig. 6). In some cases 5 or 6 conidia are joined together in this manner and produce a number of chlamydospores. Or again chlamydospores may be produced terminally on short germ-tubes (Plate XIII, fig. 6).

Chlamydospores were observed in a culture on steamed Dadap stem in a Roux tube, which had almost dried out, after 2 months. On other media chlamydospores are not produced till later. It is probable that the drying out of the culture hastened chlamydospore formation.

CULTURAL CHARACTERS OF THE FUSARIUM

The following are the characters of the fungus on different media. The cultures all originated from the single spore isolation culture and are of the same strain as the fungus used in the successful inoculation experiments.

The lengths of macroconidia were measured with an eye-piece micrometer and a 4 mm. objective. The draw-tube was so arranged that the side of one square of the eye-piece micrometer was equivalent to 18μ. For convenience, the spore-lengths were measured as a number of divisions, to the nearest tenth, rather than as a definite number of microns, and conversion was made afterwards. For this reason the points on the frequency polygons do not coincide in all cases with whole numbers of microns. Biometric calculations were based on Yule's (3) formulae.

Steamed Potato

The medium consisted of a cylinder of potato tuber cut out with a clean cork-borer, placed in a Roux tube and left in a steamer for 2 hours. After this period the tubes were sterilised for 20 minutes in an autoclave at 120°C.

After 2-3 days there was a vigorous growth of aerial mycelium at the point of inoculation and a copious production of microconidia. Later, amber-brown sporodochia of macroconidia were formed and the aerial mycelium was less in evidence. The sporodochia enlarged and in many cases fused, with the result that the whole surface of the potato was covered with what looked like a brown irregular slime, with a scanty aerial growth of grey-white mycelium. Microconidia were measured after 7 days. They ranged from 5·5 to 11μ in length and 2-4μ in breadth, with an average (of 100 spores) of 7·8μ × 3·2μ.

Macroconidia measured when the culture was 7 days old were 38-58μ × 4-5·5μ with an average (of 100 spores) of 49·2 ± ·323μ × 4·3 μ. Spores from the same culture were measured after 21 days and the figures obtained were 45-59μ × 4-5·5μ with an average of 52·1 ± ·188μ × 4·7μ. In Text fig. 1, are given frequency polygons of the spore-lengths of the spores measured at different ages.

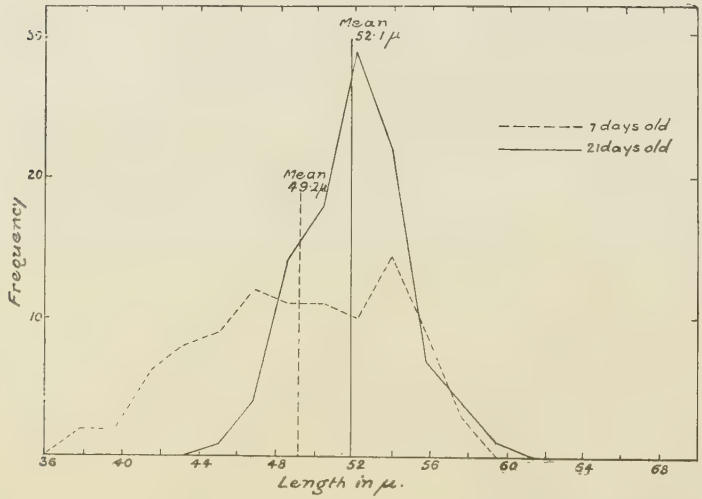

Fig. 1. Frequency distributions of spore-length of *Fusarium* grown on steamed potato.

The polygon of spore-lengths from measurements made after 7 days is much more irregular and the dispersion greater than that from measurements made after 21 days. The average spore-length after 7 days (49·2± ·323μ) .s significantly less than that after 21 days (52·0±·188μ). The polygon of spore-lengths from the 7-day old culture shows that the proportion of short to long spores is about equal, and that there is no marked preponderance of spores of any particular length. On the other hand, the polygon of spore-lengths from the 21-day old culture shows a great preponderance of spores that are of approximately the same length as the mean. This may be explained by stating that whereas in the younger culture there are spores in all stages of development, in the older culture a number of them are approaching what is, for this medium and under these conditions, a maximum length.

The spores were 3-6 septate, 64 per cent. and 65 per cent. being 5-septate in cultures 7 and 21 days old respectively.

Steamed Rice

This medium was prepared from thoroughly washed rice. The rice was placed in tubes, with sufficient distilled water to cover it and heated in a steamer for 2 hours. The tubes were then plugged and sterilised in an autoclave for $\frac{1}{2}$ hour at 120°C. One tube was not inoculated and was used as a control for colour and odour. Other tubes were inoculated and an examination after 10 days showed that relatively very few macroconidia were present. Aerial mycelium was fairly well developed, and microconidia were abundant. On no other medium were microconidia so abundantly produced as on steamed rice. The fungus caused a definite blue-violet discolouration of the rice. In old cultures the blue-violet discolouration is lost since the whole of the medium is covered with mycelium which masks the blue-violet colour; the resultant colour varies from white to grey. After 17 days amber-brown sporodochia were observed. Later, these became darker in colour. At no stage in the development of the fungus was any odour noticed. Microconidia taken from a culture 10 days old, ranged from 5-9μ × 2-4μ with a mean of 100 spores of 6·7μ × 3·1μ.

Macroconidia taken from a culture 10 days old measured 36-54μ × 4-6μ with an average (of 100 spores) of 45·1± ·403μ × 4·8μ. The spores were 3-7 septate, 52 per cent. being 4-septate. Spores from the same culture after 21 days were found to range from 45-61μ × 4-5·5μ with a mean of 53·0±·230μ × 4·7μ and were 3-7-septate with 43 and 53 per cent. 4-and 5-septate respectively. Another 100 spores were measured after 36 days. These were found to range from 43-61μ in length

with an average of 52·9±·214μ : (no width measurements were made of this group). Septation was 4-5 with 74 per cent. 5-septate. Text Fig. 2 shows the frequency polygons of the length of spores of these sets of measurements.

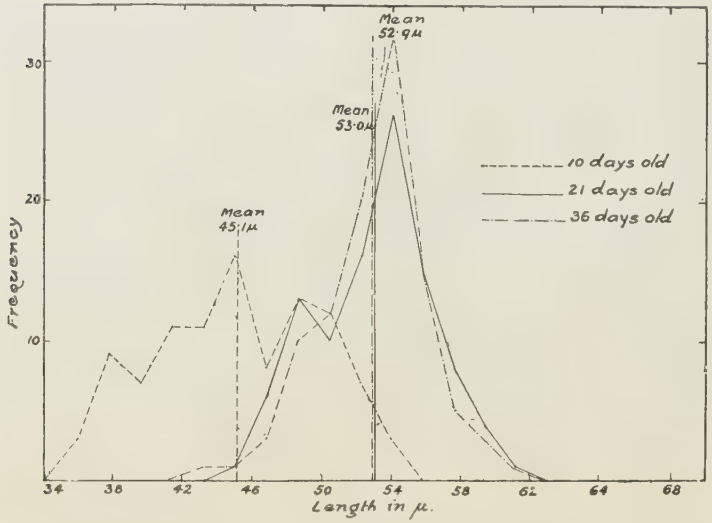

Fig. 2. Frequency distributions of spore-lengths of *Fusarium* grown on steamed rice.

The polygon of spore-lengths obtained from a culture 10 days old indicates that the spores are smaller than those from the older cultures. The distribution of spores is over a greater area and there is not, as in the case of the other polygons, a well defined " peak." These polygons again bear out the theory that the spores increase in length up to a certain maximum. The two polygons of spore-lengths from cultures after 21 and 36 days respectively are almost identical and the difference between the averages is not significant, mathematically. This means that spores from cultures on steamed rice under similar conditions do not vary in average length to any significant extent between the periods of 21 and 36 days.

Dadap Stem

This medium consisted of young green stems of Dadap (*Erythrina lithosperma*) of about $\frac{1}{2}$" diameter and $1\frac{1}{2}$" in length, washed thoroughly

in distilled water, and placed in prepared Roux tubes. These were then steamed for 2 hours and then sterilised in an autoclave for half an hour at 120°C. After inoculation there was a fair growth of white cottony aerial mycelium on the cut end (the point of inoculation) and later emerging from the leaf-scars. Microconidia were abundant after 4 days. Sporodochia were formed later and were honey-brown in colour and similar in appearance to those formed on other media. As the culture aged and dried out, the colour became darker, and, after two months, greenish streaks were observed in the sporodochia. This colour change was associated with the formation of chlamydospores.

The macroconidia were similar in shape to those on other cultures, and Text fig 3 shows the frequency polygons of the lengths of spores (one hundred in each case) measured after 4, 34, and 67 days. The septation of all the spores measured ranged from 3-6 and the majority of the spores were 5-septate. The measurements of macroconidia are given in Table III.

TABLE III

Age of culture.	Range of spore-length.	Mean spore-length.	Width range.	Mean width.
4 days	32—52μ	40·0±·365μ	4—5μ	4·25μ
34 days	47—67μ	56·0±·258μ	4—6μ	5·1 μ
67 days	41—61μ	54·0±·224μ	4—5μ	4·6 μ

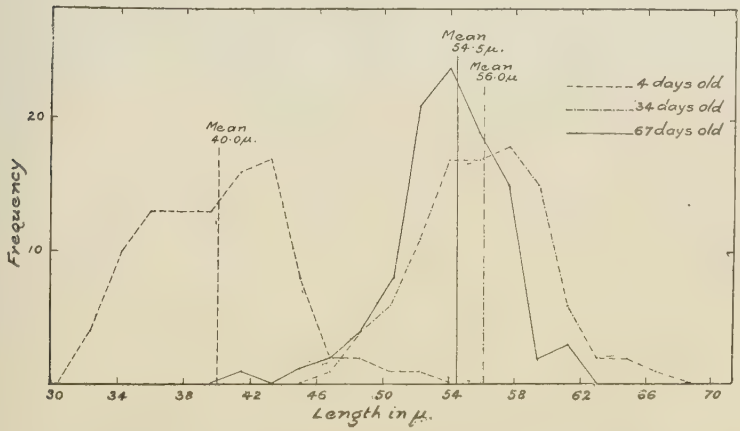

Fig. 3. Frequency distributions of spore-lengths of *Fusarium* grown on steamed Dadap stem.

It may be seen from the frequency polygons that the spores measured from cultures 4 days old are markedly shorter than those measured from cultures 34 and 67 days old, and that the largest spores are not so large as the average of the 34-day or 67-day measurements. It may be concluded from this that all of these spores are immature and have not attained their maximum length.

The mean length of spores from the 67-day old culture is significantly smaller than that of spores from the 34-day old culture. It would appear, therefore, that some factor or combination of factors comes into operation during this period which tends to reduce the mean length of spores.

It may be assumed from the above, that between 4 and 34 days there is a gradual increase in the mean length of spores until about the 34th. day, but that after that period there is a decrease in mean length, due to the operation of some factor or factors. Reference to these factors will be made later. It is obvious that there will be a number of days at or about the period of maximum growth, before any marked retrogression is apparent.

In measuring macroconidia from old cultures a large number of spores were found to have formed chlamydospores and the cells from which the protoplasm had been absorbed had collapsed. In examination of such cultures, only spores in the condition of the " norm " that is turgid and unaltered spores, were measured. It may be assumed that the majority of spores which produce chlamydospores are mature and at the point of maximum development. By ignoring full-grown spores which have formed chlamydospores, we are in effect removing a number of full-grown spores from the average sample. Consequently, the proportion of small and immature spores is relatively increased, with the result that the mean measurement of the sample is somewhat decreased. This fact would, to some extent, explain the smaller mean length of spores obtained from the 67-day old culture as compared with that of spores from the 34-day old culture.

Maize-meal Agar

This medium is prepared by boiling 25 grammes of ground maize in a little water for ½ hour, straining through muslin, making up to 250 cc. with water, adding 1½ per cent. agar and sterilising for ½ hour at 120° C. This gives a good starchy medium which favours the growth of most fungi.

Inoculated tubes give a rather sparse, evanescent growth of white cottony aerial mycelium, with a copious production of microconidia at first. After about 10 days amber-brown sporodochia are formed and these become abundant as the culture develops. The fungus dis-

colours the medium to a light grey-black colour. The microconidia are mostly oval and measure 6-9μ × 2-4μ. Four series of measurements were made of the macroconidia and a summary of these is given in Table IV.

TABLE IV

Age of culture.	Range of spore-length.	Range of spore-width.	Mean length.	Mean width.	Septation.
10 days	36—62μ	4—5·5μ	48·7±·304μ	4·7μ	4—6 (69% 5-septate)
41 days	45—66μ	4—5·5μ	56·8±·275μ	4·8μ	4—7 (55% 5-septate)
82 days (culture 1).	43—63μ	4—5·5μ	53·1±·224μ	4·9μ	4—7 (48% 5-septate)
82 days (culture 2).	45—61μ	4—5·5μ	53·4±·195μ	4·8μ	4—6 (61% 5-septate)
285 days.	38—61μ	4—6 μ	48·3±·329μ	4·9μ	4—7 (55% 5-septate)

The measurements made after 82 days were from two cultures from the same parent culture which were grown under identical conditions throughout. These were made to determine whether *Fusarium* grown on the same medium under similar conditions of temperature moisture and nutrition would give spores of similar dimensions. It will be noticed that the measurements obtained from these cultures are very similar and that there is no significant difference between the results obtained.

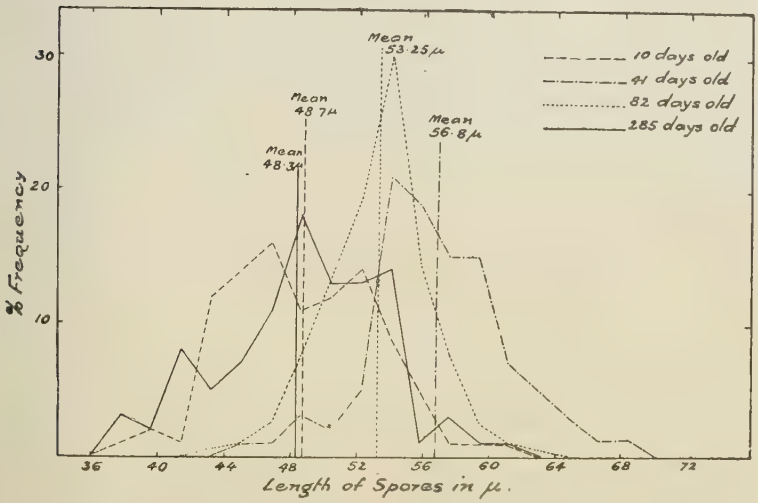

Fig. 4. Frequency distributions of spore-lengths of *Fusarium* grown on maize-meal agar.

The frequency polygons of the spore-lengths from cultures at different ages are given in Text fig. 4. These polygons indicate that the mean spore-lengths measured from a culture 10 days old are smaller than those from either the 41-day old culture or from the 82-day old cultures, but are larger than those from the 285-day old culture. The spores from the culture 41 days old are the largest, and those from the culture 82 days old are somewhat less, while after 285 days the average length of spores has diminished considerably. These measurements bear out what has been found on other media in that the average length of spores increases up to a certain maximum period and then decreases as the culture becomes older and other factors come into play.

GENERAL DISCUSSION OF THE FUSARIUM GROWN ON DIFFERENT MEDIA

Morphological characters

The general characters of the *Fusarium* on the media used are somewhat similar. There is in each case a somewhat evanescent appearance of white, or dirty-white, cottony aerial mycelium. This is accompanied at first, in all cases, by the copious production of the spores of the *Cephalosporium* stage, or microconidia. These vary in size and shape to such an extent that no systematic attempt has been made to compare their measurements. In all cases examined they were produced in a similar fashion, in heads, usually terminally on rather short lateral hyphae. The macroconidia are produced in sporodochia at rather a later stage and these sporodochia were found to be of a brown colour throughout the range of media. The macroconidia were observed to be similar in shape or rather, range of shapes, since they are somewhat variable on any one medium. Similar characters of variation in length of macroconidia have been observed on all media, but cultures of the same age, grown under similar conditions, on different media, do not necessarily produce spores with the same average length.

Studies of spore-lengths

In reading through literature on the subject of the genus *Fusarium* very few papers have been seen which have mentioned the application of biometric methods to the study of the spore-measurements. Most authors have been content to give the range of length of spores and but few mention the number of spores measured or the average length. It seems to have been assumed by most workers that the variability of the spores is so great that no significance can be attached to them. Brown (1) has shown that variations of a temporary and permanent

nature can be effected by drastic changes in media and conditions. While working on the *Fusarium* pathogenic on *Erythrina lithosperma* the author has found that the fungus, as is shown by a measure of the spore-length, shows significant differences on different media grown under similar conditions of light, temperature, and moisture, but at the same time has observed some constant characters with regard to relative variation of spore-length with age.

The first point to be emphasised is the fact that under similar conditions, on the same medium, and with cultures of the same age, the average length of spores was found to be within the range of probable error. Two sub-cultures on Maize-meal agar were made from one parent culture. After 82 days 100 spores from each culture were measured. The ranges of spore-lengths were 43-63μ in the first culture and 45-61μ in the second culture. The average spore-lengths were $53{\cdot}1 \pm {\cdot}224\mu$ and $53{\cdot}4 \pm {\cdot}195\mu$ with a difference of $\cdot 3 \pm {\cdot}436\mu$, which difference is within the range of the probable error. Thus the average spore-lengths of the two cultures may be taken as being identical. There is no reason to suppose that this should be otherwise with similar pairs of cultures at other ages and on other media.

The measurement of the spore-lengths of cultures at different ages has given results which are similar with each medium. It has been found that the average spore-length in similar cultures has increased up to a certain age, has kept constant for a time and has decreased after that period. That is to say, in any one culture the average spore-length will increase fairly rapidly up to a period when it is at its maximum for that medium under a given set of conditions, and that after that period, the average length of spores in a normal condition of turgidity, etc., will slowly decrease. It seems that there are several factors which can influence the average length of spores. Firstly, a number of mature conidia produce chlamydospores and consequently, as these are not measured, the mean spore-length of the sample is to some extent reduced. Secondly, there is the staling effect of the fungus on the substratum, as has been discussed by Brown (1) and Pratt (2). This would influence the size of the later-formed macroconidia. Thirdly, in old cultures there is a drying out of the culture medium which might also affect the size of macroconidia. Lastly, in old cultures in the presence of abundant moisture, germination of conidia has been observed with the production of secondary conidia, which when measured have been of less length than the primary conidia. All these factors would tend to reduce the mean spore-length obtained from average samples.

In Table V the evidence for the increase and decrease of spore-length with age is given.

TABLE V

Average spore-length on maize-meal agar.	Average spore-length on Steamed Dadap stem.	Average spore-length on Steamed Potato.	Average spore-length on Steamed Rice.
48·7±·304 μ (10 days).	39·96±.365 μ (4 days).	49·2±·323 μ (7 days).	45·1±·403 μ (10 days)
56·8±·275 μ (41 days).	56·0 ±·258 μ (34 days).	52·0±·188 μ (21 days).	53·0±·230 μ (21 days)
53·1±·224 μ (82 days).	54·0 ±·224 μ (67 days).	—	52·9±·214 μ (36 days)
53·4±·195 μ (82 days).	—	—	—
48·3±·329 μ (285 days).	—	—	—

It will be seen from this table that there is no significant difference between the average spore-lengths of the *Fusarium* on steamed rice measured after 21 and 36 days. This means that with cultures grown on steamed rice under similar conditions, the probability is that the average spore-length will be approximately equal whether measured after 21 days or 36 days, and it is natural to assume that it will be the same during the period, between 21 and 36 days.

On steamed Dadap stem, the difference between the average length of spores measured after 34 and 67 days is 2·0±·342μ. This difference is significant. (A significant difference is defined as a difference which is at least five times as great as the probable error of that difference, which error is obtained by taking the square root of the sum of the squares of the probable errors of the two results). Therefore, in this case it can be said that the probability is that, under similar conditions, the average spore-length measured from cultures on Dadap stem after 34 days will be greater than that measured after 67 days. Presumably, at 67 days other factors mentioned above have come into play and the average spore-length has begun to decrease. Thus, at this age, the culture has passed the period of optimum growth, as judged by measurement of spore-lengths.

The differences between the mean spore-length of the 41-day old culture on maize-meal agar and the mean spore-lengths of the two 82 day old cultures on this medium are 3·7±·355μ and 3·5±·337μ respectively. Both differences are significant and indicate that the average length of spores from a culture on maize-meal agar measured after 82 days will be less than that of spores from a culture 41 days old. Similarly

it can be demonstrated that the average length of spores from a culture 285 days old will be considerably less than that of spores from a culture 82 days old. These facts seem to justify the assumption that the average length of spores decreases after the period of maximum or optimum development which ranges around 41 days for this medium.

The measurements from cultures up to 10 days old are for each culture medium significantly less than the average lengths of spores from cultures over 20 days old. The difference in each case is marked and shows that the average spore-length on any one medium increases quite rapidly up to a point of optimum development, given uniform conditions.

The points discussed above have led the following conclusions. The development of spores, as measured by the average spore-length, of this *Fusarium* is comparable on different media, and consists of a fairly rapid increase in length up to a certain period of optimum development which continues for some time. After this period other factors enumerated above come into play and the average length of spores consequently diminishes.

From the above it would appear that within the period of, say, from 20-50 days after inoculation the average spore-length is approximately the same on any one medium provided that conditions are kept approximately constant. It should, therefore, be possible to compare the biometric constants of the spore-lengths of the fungus on different media measured at any time during that period. The comparison should show whether, other things being approximately equal, the measurement of spore-lengths is or is not the same on different media. In Table VI are given the biometric constants of the spore-lengths of the fungus measured during this "optimum" period.

TABLE VI

Culture Medium.	Age of Culture.	Mean μ.	Median μ.	Mode μ.	Standard Deviation μ.	Skewness.
Maize-meal Agar.	41 days.	56·75±·275	57·21	58·31	4·10±·196	—·336±·096
Steamed Potato.	21 days.	52·11±·188	52·11	52·11	2·79±·133	0±·096
Steamed Rice.	21 days.	52·97±·230	53·37	54·16	3·42±·163	—·348±·096
Dadap.	34 days.	56·02±·258	56·07	56·18	3·83±·183	—·423±·096

The difference between the mean lengths of spores measured from cultures on the different media is significant and is greater than the difference which would normally be expected through errors in sampling. Thus it can be said that according to the results obtained from these examinations, the length of spores of this *Fusarium* is not the same at

the period of "optimum" development on the four different media used. Other conditions were in each case very favourable for the growth of the fungus, the laboratory temperature range during the whole period being 22°-28°C., the cultures saturated with moisture up to and during the period of optimum growth, and the light being the same for all. It is, therefore, assumed that any difference observed in the length of spores of the fungus during this period may be attributed to the difference of medium.

CONTROL

Dadap is commonly used at "mid-country" elevations as a green manure for tea. The *Fusarium* disease is most serious during a period of wet weather, immediately after lopping. The inoculation experiments show that the *Fusarium* is commonly a wound parasite, and given suitable conditions, it may cause a serious die-back disease from the cut ends of pruned branches. Dadap is not of sufficient economic importance to warrant expensive treatment for a sporadic disease of this nature. The best method of prevention is to avoid lopping Dadap in wet weather and if practicable, to tar the cut ends. When the disease appears the affected branches should be cut back to healthy tissue as early as possible, and the diseased tissue burned. The fungus which causes this disease produces an abundance of air-borne spores, so that given suitable conditions it might easily become epidemic. The burning of the diseased tissues as early as possible would minimise the risk of such an occurrence.

SUMMARY

An investigation of a die-back disease of Dadap (*Erythrina lithosperma*) has been made. The die-back occurs particularly after lopping in wet weather.

A species of *Fusarium* obtained from the diseased tissue has been proved by inoculation experiments to be the pathogen.

A study of the spore-lengths of the fungus grown on different media under similar conditions has been made and the results compared biometrically.

An analysis of the figures obtained shows that, while the fungus (as judged by the average length of spores) varies on different media, there is for each medium examined a period of "adolescence," a period of "optimum growth," and after this a period of "retrogression." The factors influencing these periods are discussed.

For control, lopping should be avoided in wet weather, and affected tissue should be removed and burned.

My thanks are due to Dr. C. H. Gadd, of this Department, for his kindly criticism and advice.

REFERENCES

1. Brown, W. A study of forms of *Fusarium* occurring on apple fruits—Rep. Imp. Bot. Conf., London 1925, pp. 339-346.
2. Pratt, C. A. General and chemical investigation of staling by *Fusarium*—Ann. Bot. XXXVII 155, pp.563-595.
3. Yule, C. U. Introduction to study of statistics, 1911.

EXPLANATION OF PLATE XIII

1. Types of macroconidia from culture × 550.
2. Types of microconidia from culture × 1400.
3. Conidiophores × 550.
4. Chlamydospores on submerged mycelium in culture × 550.
5. Chlamydospores on aerial mycelium × 550.
6. Chlamydospores developed from conidia × 550.

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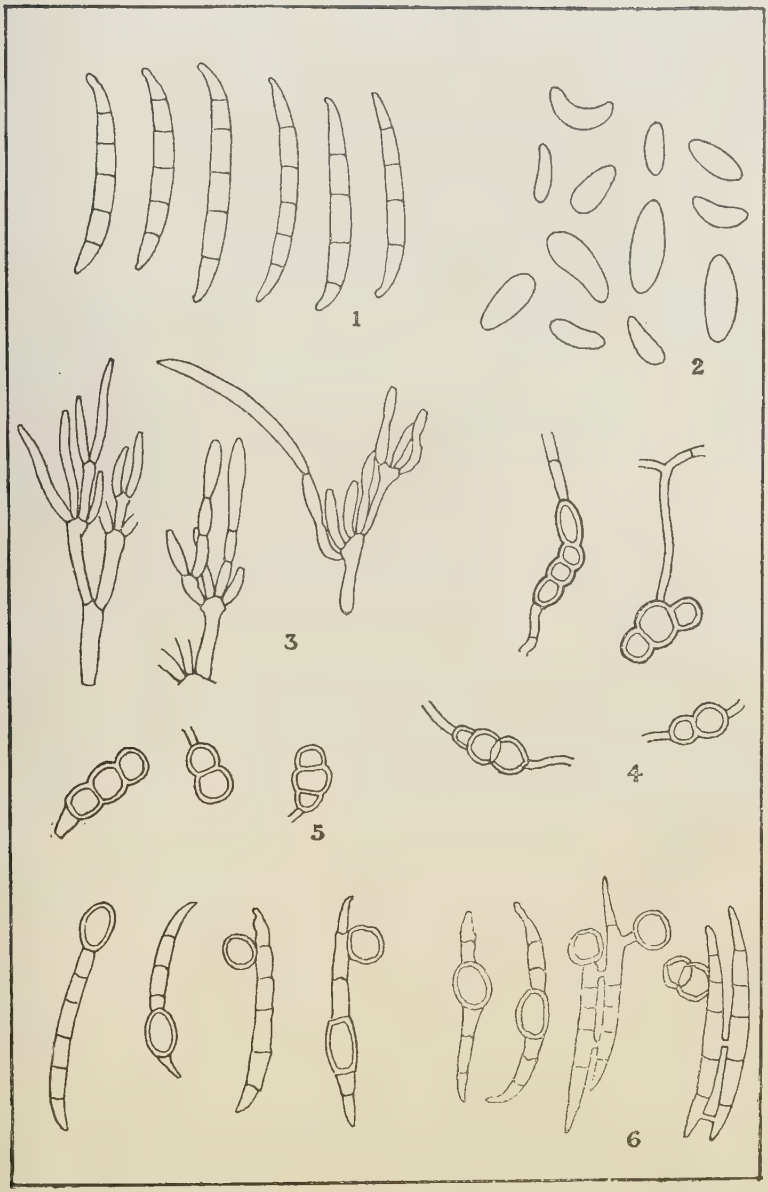

Fusarium Disease of Dadap.

Fruit Diseases of Chillies

BY

L. S. Bertus

Assistant in Mycology, Department of Agriculture, Peradeniya

WITH TWO PLATES

In 1923 a disease was reported on chilli fruits in the plots of the Economic Botanist at Peradeniya. On examination of a large number of diseased fruits three fungi were found, a *Vermicularia*, a *Colletotrichum* and a *Gloeosporium*. Very often two of these fungi were found on the same fruit. With the aid of a hand lens the *Vermicularia* could be easily distinguished from the *Gloeosporium* by the presence of bristly hairs in the fructification; similarly the *Colletotrichum* could sometimes be distinguished from the *Gloeosporium*. It is difficult to distinguish the *Colletotrichum* from the *Vermicularia* because both possess setae, although the setae of the *Vermicularia* are usually more abundant and conspicuous. As these fungi were found associated, it was suspected that they might have a common perfect stage. Examination of many diseased fruits did not show the presence of a perfect stage on any of them, although they were plucked, placed in a moist chamber and examined from time to time. Individual fruits were selected which had only one fungus present and pure cultures made with single spores in order to find out if possible if a common perfect stage would develop in culture.

Later, in a plot of chillies growing near the laboratory diseased fruits were picked which had a *Colletotrichum* on them and also a perithecial fungus. Single conidia and ascospores were taken into culture and inoculations made on fruits in the field and under laboratory conditions, to prove that the perithecial fungus found in nature is the perfect stage of the *Colletotrichum*.

In the early stages the diseases caused by these fungi cannot be distinguished as their symptoms are similar. The *Vermicularia* does more damage than the others, as it spreads to the branches via the fruit-stalks and kills them back gradually.

As no fresh outbreaks of fruit disease have been reported and as chilli is not grown on an extensive scale, it is not possible to estimate the amount of loss caused by fruit disease in Ceylon.

COLLETOTRICHUM NIGRUM E. & HALST. PERITHECIAL STRAIN

In a plot of chillies growing near the laboratory diseased fruits were found which bore fructifications of a *Colletotrichum* together with the perithecial stage of an ascogenous fungus under such conditions that it appeared probable that the ascomycete was the perfect stage of the *Colletotrichum*.

Both fungi were taken into pure culture and grown in distilled water, Raulin neutral medium, and maize-meal agar in order to prove by cultural study and inoculation that the perithecial stage found in nature on the fruit is the perfect stage of the *Colletotrichum*. Single spore cultures were readily obtained from the conidia of the *Colletotrichum* and the ascospores of the ascomycete by the plating method.

Inoculations were made from pure cultures of both fungi on chilli fruits in the field, plucked fruits in sterile tubes, and on potato slab and chilli fruits sterilised in Roux tubes.

The disease in nature. The first symptom of the disease is a slight dirty brown discolouration on the ripening fruit. This discolouration spreads rapidly, becomes darker and the whole surface of the fruit may appear sodden. In some cases the fruit drops to the ground in a rotten condition ; in others it remains attached to the bush, and shrivels up, but does not fall till quite dry. The fruit stalk may become infected, but usually the disease does not spread to other parts of the plant. Small black points appear early on the diseased fruits ; these are the fructifications or fruiting bodies of the fungus which cause the disease. At the time the fruit falls, it is usually covered by fruiting bodies.

A green fruit about half-grown, on a bush in the open, showed a slight discolouration light brown in colour, near the base of the fruit stalk. This discolouration extended a few millimetres and fructifications were formed over the discoloured area and extended over the apparently healthy, green portion in the form of small black points, single or massed together. On examination the fungus was found to be a *Colletotrichum*. Later, small greyish bodies were also formed which turned black. These were also fructifications of the same fungus. The fruit was picked and placed in a sterile petri-dish and when examined ten days later perithecia had developed. On examining more diseased fruits on the same bush, both perithecia and acervuli were found. The perithecia on the different fruits were identical.

Pieces of the diseased fruits were embedded and microtomed for examination. The acervuli are scattered or gregarious, black, erumpent, saucer or bowl shaped, up to 0·65 mm. diameter. The conidiophores are hyaline, septate, sometimes branched, rarely non-septate, up to 70 μ long and 3-4 μ diameter. The setae are dark brown, lighter coloured at the tip, septate, rigid, straight or slightly curved, up to 160μ long, 4-5μ diameter in the middle, and up to 8μ diameter at the base. The conidia are unicellular, hyaline, cylindrical, straight or slightly curved, pale pink in mass, 12-23 × 4-7μ, with a mean (50 spores) of 18 × 5·4μ.

The perithecia are formed on a loose indefinite stroma of light-brown interwoven hyphae. They vary in shape from globose to flask-shaped, are dark-brown in colour, scattered or clustered, up to 245 μ high and 184μ diameter. The yellow-brown parenchymatous wall varies in thickness in different perithecia from 15 to 35μ. The wall at the papilla (when present) is of a lighter colour and is thinner than at other parts of the perithecium. Paraphyses are lacking. The asci are cylindrical or clavate usually with a short stalk expanded at the base, and measure 42-65 × 8-13μ (Plate XV, figs. 5, 6, 7). The ascospores, 8 in number, are roughly arranged in two rows within the ascus. They are unicellular, curved, hyaline or pale brown, 12-21 × 5-9μ with a mean (50 spores) of 17·5 × 6·2μ.

The following examples illustrate the variation in shape and size of the perithecia :—

(*a*) Globose with conical apex (papilla) ; height 200μ, diameter 184μ; wall 35μ thick ; at base slightly thicker and at apex about 18μ (Plate XV, fig.1).

(*b*) Conoid ; height 175μ diameter 140μ, wall 35μ thick ; at base slightly thicker, at apex 18μ.

(*c*) Flask-shaped, fused with another perithecium ; height 245μ, diameter 122μ, wall about 18μ thick (Plate XV. fig. 2).

(*d*) Conoid ; height 175μ, diameter 105μ, wall 25μ thick.

(*e*) Conoid ; height 140μ, diameter 100μ, wall 15μ thick. This perithecium is fused with an acervulus with a diameter at base of about 100μ, (Plate XV, fig.4).

(*f*) Globose with conical apex ; height 140μ, diameter 150μ; wall 20μ thick.

Cultures from single conidia

Germination in water.—In water, the conidia, whether taken from the fruit in nature or from cultures, germinate in four to seven hours. The germ-tubes may form intercalary chlamydospores (Plate XIV, fig. 4)

or terminal appressoria (Plate XIV, figs. 1, 2). The appressoria are irregular dark-brown bodies, thick-walled and with granular contents, 6-13 × 5-8μ. The chlamydospores are lighter brown in colour, their contents more homogeneous, and their shape more regular. Appressoria do not develop on all the germ-tubes, and consequently cannot be considered a definite character. Growth may occur from an appressorium and the hyphae may again terminate in another appressorium (Plate XIV, fig. 3).

Raulin neutral medium.—Single conidia which had germinated in a petri-dish after plating were picked out and transferred to Raulin medium slants.

The mycelium was at first white, then greenish, then light olive grey. At this stage small black bodies and pink pustules or spores were scattered over the surface. By the tenth day the mycelium formed a purplish grey felt, with small greyish or blackish bodies scattered over it; and by the fourteenth day, black pulvinate masses, up to 4 mm. in diameter, and more or less regular, together with erect sclerotium-like bodies, are found on the felted layer.

Microscopic examination.—A stroma varying in depth from 0·15 mm. to 0·23 mm. is formed on the culture medium. On this stroma a loose film of mycelium is present. The acervuli are pulvinate, pseudoparenchymatous masses, made up of interlaced, closely septate, brown mycelium, situated on the stroma, underneath the loose film of mycelium. They occur singly or may stretch indefinitely over the surface of the stroma, and are black in mass, but produce pink pustules of spores. The setae arise from the pseudoparenchymatous base, and are dark-brown, septate, rigid, straight or geniculate, acute and paler at the apex, up to 210μ long and 3 to 5μ diameter; they vary in number in different acervuli, from few to many. The conidiophores arise from the same base as the setae and are simple, hyaline or tinted-brown, non-septate or septate, straight, or irregularly swollen, up to 50μ long and from 3 to 5μ diameter. Very often the lower cells of a septate conidiophore are light-brown. The conidia are hyaline, unicellular, straight or slightly curved, cylindric, pale pink in mass, 14-21 × 4-7μ, with a mean (50 spores) of 17·1 × 5·5μ. The black pulvinate masses and the erect sclerotium-like bodies are simply masses made up of numerous perithecia, some distinct, some fused together, and often with stromata containing numerous perithecia or loculi. These masses usually grow upwards from the stroma on the culture medium, raising the loose film of mycelium on the surface, but sometimes they extend irregularly downwards into the stroma of the culture medium or into the culture medium itself. The perithecia of which these masses are composed may be spherical, globose, oval, or

rectangular oval. The thickness of the wall in different perithecia varies up to 30μ. The asci which are plentifully developed in these perithecia and loculi, are clavate or cylindrical 42-55 × 8-13μ, with a short stalk up to 10μ long and 3μ diameter, expanded at the base, or sometimes sessile. The ascospores are hyaline, unicellular, slightly curved, elliptic, 13-23 × 4-8μ, with a mean (50 spores) of 17·3 × 5·8μ.

Details are here given of a typical pulvinate mass and an erect sclerotium-like body.

(A) *Pulvinate mass.* Greatest width 2·3 mm.; greatest height 1·8 mm. The whole body is covered with a loose film of mycelium. Shape and dimensions of a few of the perithecia in the mass are given below.—

(*a*) Globose, width 200μ, height 175μ, wall 20μ thick.
(*b*) Spherical, diameter 140μ, wall 15μ thick.
(*c*) Vertically oval, height 175μ, width 135μ, wall 17μ thick.
(*d*) Spherical, diameter 120μ, wall 25μ thick.

This pulvinate mass in addition to the numerous perithecia grouped together contains a stroma containing numerous loculi (perithecia) filled with asci. The stroma is almost spherical in shape with a diameter of about 0·46 mm. It has a distinct wall 30μ thick.

(B) *Erect sclerotium-like body.* Greatest height 1·5 mm., width 1·15 mm. Shape and dimensions of a few of the perithecia are here given.

(*a*) Spherical, diameter 210μ, wall 25μ thick.
(*b*) Spherical, diameter 140μ, wall 20μ thick.
(*c*) Oval, height 140μ, width 200μ, wall 20μ thick.
(*d*) Rectangular oval, height 135μ, width 250μ, wall 30μ thick.

Maize-meal agar. The agar slants were inoculated with a pure culture. The growth on this medium was similar to that on Raulin neutral agar, but not so luxuriant.

Microscopic examination. The characters of the perithecia and stromata are similar to those on Raulin neutral agar. The conidia measure 12-21 × 4-7μ with a mean (50 spores) of 16·5 × 5·3μ; the conidiophores are up to 52μ long and 4 μ diameter; the setae up to 200μ long and up to 6μ diameter. The asci are 38-60 × 7-11μ and the ascospores 14-20 × 5-7μ with a mean (50 spores) of 17·1 × 5·84μ. Perithecia are also developed in this culture medium from old acervuli. In Plate XV, fig. 6, a section of an old acervulus is shown. From the base of this acervulus, *i.e.* from the pseudoparenchymatous layer, setae are produced. The basal cells also produce brown hyphae which grow out and radiate in strands in the shape of an open fan and terminate in perithecia which may be single or fused together. The perithecia

are similar to those found in the pulvinate masses. The thickness of the walls in the different perithecia varies up to 20μ and the diameter or greatest length up to 200μ.

Cultures from single ascospores

Germination in water. The ascospores germinate in water in about the same time as the conidia. As in the case of the latter the germ-tubes may form intercalary chlamydospores or terminal appressoria (Plate XIV, figs. 12, 13, 14). A spore may bud off a secondary condium from one end and produce a hypha at the other end (Plate XIV, fig. 15). The secondary conidia are almost spherical or fusoid in shape and measure 8-11 × 5-7μ. In old cultures, conidia similar in dimensions to those of the *Colletotrichum* are produced at the end of branched germ-tubes (Plate XIV, fig. 10).

Raulin neutral medium. The growth and microscopic characters on this medium are similar to those of the conidia on the same medium.

Microscopic examination. Individual acervuli vary in height from 0·11 mm. to 0·25 mm. and in breadth from 0·22 mm. to 1·15 mm. The setae are 75-192μ long and 3-5μ diameter ; they occur in acervuli in one part of the culture, while in other parts of the same culture they are absent. The conidiophores are up to 60μ long and 3 to 5μ diameter, and the conidia 12-27 × 4-8μ, with a mean (50 spores) of 18 × 5·26μ. The perithecia and perithecial stromata occur in the film of hyphae on the stroma of the culture medium, on the film, and on the stromata of the culture medium. Where a crack occurs in the culture medium, hyphae enter and form a network and in this network perithecia are formed. A peculiarity noticeable is that asci are not developed in perithecia except in the perithecia and loculi of the pulvinate masses found on the stroma of the culture medium. The asci are 40-70μ × 9-12μ ; when viewed in mass they have a yellowish tinge. The ascospores are 14-21 × 5-7μ, with a mean (50 spores) of 17·54 × 5·6μ. When asci from the pulvinate masses are teased out and examined, ascospores are found budding off fusoid conidia while still inside the ascus (Plate XIV, figs. 8, 9.).

The results of an examination of a typical pulvinate mass composed of perithecia, and of perithecia found in different parts of the medium are here given.—

(A) *Pulvinate mass.* On the stroma formed in the culture medium (Plate XV, fig. 5). Greatest height 1·64 mm. ; greatest width 1·38 mm. containing numerous perithecia and loculi in which asci are formed. The whole body is covered by the loose hyphae which grow as a film on

the stroma of the medium. With growth, the film is elevated. Dimensions and shape of a few perithecia in the mass are :—

(*a*) Spherical, diameter 125μ, wall 17μ thick.
(*b*) Spherical, diameter 52μ, wall 7μ thick.
(*c*) Spherical, diameter 70μ, wall 9μ thick.
(*d*) Spherical, diameter 135μ, wall 20μ thick.
(*e*) Globose, height 140μ, width 157μ, wall 15μ thick.
(*f*) Globose, height 175μ, width 190μ, wall 18μ thick.
(*g*) Vertically oval, height 135μ, width 70μ, wall 12μ thick.

(B) *Perithecia in the film of hyphae on the stroma of the culture medium.* These are usually spherical or globose and occur singly or fused together :—

(*a*) Spherical, diameter 158μ, wall 30μ thick.
(*b*) Spherical, diameter 70μ, wall 15μ thick.
(*c*) Spherical, diameter 142μ, wall 20μ thick.
(*d*) Globose, height 87μ, width 120μ, wall 18μ thick.
(*e*) Conoid, height 140μ, width 115μ, wall 15μ thick, thin near the apex.

(C) *Perithecia on the stroma of the culture medium* :—

(*a*) Globose, height 140μ, width 175μ, wall 12μ thick.
(*b*) Almost spherical, diameter 160μ, wall 15μ thick.

(D) *Perithecia in a crack in the culture medium* :—

(*a*) Globose, width 245μ, height 175μ, wall 30μ thick.
(*b*) Spherical, diameter 100μ, wall 18μ thick.
(*c*) Almost spherical, diameter 175μ, wall 17μ thick.

Maize-meal agar. The growth on this medium is identical with that of a single conidium on the same medium.

Microscopic examination. A single acervulus may have a diameter up to about 0·46 mm. The setae are up to 250μ long and 4μ diameter ; about 5μ diameter at the base. They vary in number in different acervuli, being few in some and many in others. The conidiophores are 3-5μ diameter and up to 40μ long. Very often in old cultures, the lower cells of the conidiophores are tinged light-brown. The conidia measure 12-20 × 5-7μ, with a mean (50 spores) of 16 × 5·7μ. When individual pustules were examined, conidia light-brown in colour were found in the mass which had germinated and possessed germ-tubes also light-brown in colour. The perithecia are usually spherical, globose, conoid or oval, varying in length up to 210μ and in width up to 122μ. The thickness of the walls in the different perithecia varies from 15-30μ. Spherical and globose bodies were found embedded in the culture medium.

These resembled perithecia, but contained no asci. Instead of asci a loose hyphal growth was present. These bodies occur singly or many may be fused together. The asci are 38-62 × 8-12μ and the ascospores 14-22×5-8μ, with a mean (50 spores) of 17×6μ. Ascospores tinged brown were found having a septum, occasionally two septa, rarely three.

Comparison of the behaviour of conidia and ascospores in culture

The conidia germinate in water in about four to seven hours and in about twenty-four hours a large number produce appressoria.

In Raulin neutral medium and maize-meal agar both the conidial and the perithecial stages are obtained. In the latter medium old acervuli were found producing perithecia.

In Raulin neutral medium the conidia measure 14-21 × 4-7μ, with a mean (50 spores) of 17·1 × 5·5μ ; the conidiophores up to 50μ long and 3-5μ diameter ; setae up to 210μ long and 5μ diameter ; asci 42-55 × 8-13μ ; ascospores 13-23 × 4-8μ with a mean (50 spores) of 17·3 × 5·8μ.

In maize-meal agar the conidia measure 12-21 × 4-7μ, with a mean (50 spores) of 16·5 × 5·3μ ; the conidiophores up to 52μ long and 4μ diameter ; setae up to 200μ long and up to 6μ diameter ; asci 38-60 × 7-11μ ; ascospores 14-20 × 5-7μ with a mean (50 spores) of 17·1 × 5·84μ.

The ascospores germinate in water in about the same time as the conidia and in about eighteen hours some germ-tubes terminate growth in appressoria. In cultures forty-eight hours old, germinated ascospores were found producing conidia, similar to those found in nature, at the end of branched germ-tubes.

In Raulin neutral medium and maize-meal agar both the conidial and the perithecial stages are produced. The mode of growth in both these media is similar to that of a single conidium in the coresponding medium.

In Raulin neutral medium the conidia measure 12-27 × 4-8μ, with a mean (50 spores) of 18 × 5·26μ ; the conidiophores up to 60μ long and 3-5μ diameter ; setae up to 192μ long and up to 5μ diameter ; asci 40-70 × 9-12μ ; ascospores 14-21 × 5-7μ, with a mean (50 spores) of 17.54 × 5·6μ.

In maize-meal agar the conidia measure 12-20 × 5-7μ, with a mean (50 spores) of 16 × 5·7μ ; the conidiophores up to 40μ long and 3-5μ diameter ; setae up to 250μ long and up to 5μ diameter : asci 38-62 × 8-12μ ; ascospores 14-22 × 5-8μ with a mean (50 spores) of 17 × 6μ.

Conclusion

A single conidium from a chilli fruit in nature when taken into culture produces both a conidial and perithecial stage. A single ascospore from a chilli fruit in nature when taken into culture also produces a conidial and perithecial stage. The conidia, conidiophores, asci, and ascospores of both fungi are practically of the same dimensions. The modes of growth of both fungi on the two culture media are very similar. A germinated ascospore was found producing typical conidia. The dimensions of the conidia and ascospores in culture are similar to those found in nature. Under these circumstances, it is clear that the perithecial stage found in nature is the perfect stage of the *Colletotrichum*.

The *Colletotrichum* is no doubt *Colletotrichum nigrum* E. and Halst. and the perithecial stage *Glomerella piperata* (Stonem.) S. and v. S.

Inoculations

From conidia.

Experiment 1. On chilli fruits in the open. Seven ripe and three green fruits on plants in pots were inoculated by placing small pieces of the culture medium containing mycelium on the surface of the fruits. The pots were exposed in the open in the pot-culture house to sun and rain. On the following day as the inoculum appeared somewhat dry it was moistened with a few drops of distilled water. Mites were noticed running over some of the inocula. Six days after inoculation fructifications were produced all over the surface of one ripe fruit; and on the following day this fruit had fallen and was shrivelled. It was placed in a sterile petri-dish, and, seven days later, the fructifications were prominent, in distinct longitudinal rows, both perithecia and acervuli being present. Seven days after inoculation, three other ripe fruits and one green fruit, which had begun to ripen showed signs of successful infection. On one, the whole surface on one side of the fruit was covered with fructifications, acervuli being present in abundance with perithecia sparsely scattered. The other three fruits had fructifications only around the inoculated spot, and these consisted of acervuli only. These latter fruits were picked and placed in sterile petri-dishes, and a fortnight later, they were sodden, with masses of black fructifications, which occasionally formed a crusted mass; in these masses perithecia were found. In all cases where the fruits took infection the fruit stalks were also involved, fructifications being formed on them later.

When infection begins, the inoculated spot turns a dirty-brown colour, which continues to spread, and the black fructifications develop on its surface. Very often fructifications are formed on the apparently healthy green portion. When a fruit which bears fructifications is

opened, it is found that the seeds are covered with a weft of greyish hyphae, and masses of hyaline, thin hyphae are present inside the tissue of the seed. Very often the hyphae form sclerotium-like masses outside and inside the seed, and on the inner surface of the skin of the fruit.

Five inoculations failed to take, probably because the inoculum dried up before the hyphae had penetrated the fruit, or because it was disintegrated by mites. Fruits on plants in pots which were placed as a control by the side of the pot containing the inoculated fruits did not develop any disease.

Experiment 2. On chilli fruits in Roux tubes. Two fruits, one ripe and one green, but full grown, were washed in distilled water, placed in sterile Roux tubes and inoculated with a piece of the culture medium from a pure culture. After three days a slight discolouration was seen round the inoculated spot of the green fruit ; this discolouration spread very slowly ; in twenty-two days acervuli were produced and in about one month perithecia appeared. In the ripe fruit no external discolouration was seen, but small black bodies appeared over the surface near the stalk end in about three weeks ; five days later these had increased in number and were developing towards the lower end of the fruit, while loose white hyphae were sparingly scattered all over the surface. The black bodies were masses of perithecia fused together. On opening the fruit the seeds were seen to be enveloped in a greyish white mycelium.

Experiment 3. On chilli fruits sterilised by boiling in Roux tubes. In a week's time the whole fruit was one black mass consisting of perithecia fused together. Three fruits were inoculated from a pure culture and all were successful.

Experiment 4. On sterilised potato slab. A potato was cut into slabs which were placed in Roux tubes, with a piece of cotton at the base, sterilised in an autoclave and inoculated with a piece of the culture medium. In three weeks' time the whole slab was a black mass, consisting of separate perithecia and perithecia aggregated together forming a crust. Perithecia had also developed in the cotton wool at the base. Two inoculations were made in two different tubes and both behaved alike, except that, in one, a few scattered acervuli were present.

From ascospores.

Experiment 1. On chilli fruits in the open. Five inoculations were made on fruits in the open, in a manner similar to that employed for the inoculations with the cultures from conidia. Two fruits were inoculated after wounding with pin-pricks and three without wounding. In five days' time the wounded inoculations showed signs of infection

and in thirteen days perithecia and acervuli developed. The unwounded inoculations failed to take.

Experiment 2. On chilli fruits sterilised by boiling in Roux tubes. Green fruits were boiled in water, placed in Roux tubes, and inoculated by placing a small piece of the culture medium containing hyphae on the surface of the fruits. In the following day white hyphae had grown luxuriantly from the inoculum and had spread over the surface of the fruits. Five days later, the whole fruit was enveloped in a mass of small black bodies and pink pustules of spores intermingled with loose hyaline hyphae. One fruit had no pink pustules, but the fructifications appeared on one side of the fruit in the form of a black crust. No setae were present in the pink pustules of spores, but when these spores were transferred to maize-meal agar slants, acervuli with setae developed. Four inoculations were made in four different tubes and all behaved alike. Two tubes kept as a control did not develop any fungus.

Experiment 3. On sterilised potato slab. The slabs were put into Roux tubes with cotton wool at the base and inoculated with a piece of the culture medium. Three days later white hyphae spread from the point of inoculation, over the surface of the slabs. In six days, from inoculation, the whole of one side of the slab was covered with perithecia, which also occurred on the cotton wool. When the culture was twenty-two days old, the whole slab was covered with perithecia. On one side of the slab, the mycelium grew as a compact film with perithecia embedded in it. All the asci were stalked similar to those grown on Raulin and maize-meal agar. This substratum appears to be very favourable for the abundant production of perithecia.

Eight inoculations were made on ripe fruits with pure cultures from conidia and five were successful ; four were made on green fruits and two were successful. In all twelve inoculations were made and seven took effect producing both stages of the fungus. On chilli fruits sterilised by boiling in Roux tubes and on sterilised potato slab the perithecial stage was obtained.

Three inoculations were made on fruit with pure cultures from ascospores and all failed to take effect ; two were made after wounding with pin-pricks and both succeeded, producing both stages of the fungus. On chilli fruits sterilised by boiling in Roux tubes both stages were produced, but on sterilised potato slab only perithecia were formed.

COLLETOTRICHUM NIGRUM E. AND HALST. NON-PERITHECIAL STRAIN

Diseased chilli fruits were found which bore fructifications of a *Colletotrichum* but not associated with a perithecial stage. The symp-

toms of the disease and its microscopic characters were similar to those of the perithecial strain. The acervuli were up to 0·55 mm. diameter; the setae up to 120μ long, 3-5μ diameter in the middle, and a little broader at the base; the conidiophores 2-4μ diameter and 12-40μ long. The conidia measured 12-23 × 4-6μ, with a mean (50 spores) of 17 × 4·5μ.

The conidia germinate in water in about the same time and in a similar fashion to the conidia from the perithecial strain. Single-spore cultures were readily obtained and grown on maize-meal agar. The mode of growth on this medium was similar to that of the perithecial strain. The setae were up to 200μ long and up to 5μ diameter; the conidiophores up to 38μ long and 3μ diameter; the conidia 12-21 × 4-6μ with a mean (50 spores) of 16·3 × 4·7μ. No perithecia developed in the culture medium, but instead there were small black bodies usually spherical or globose embedded in it, scattered or clustered having distinct dark brown walls. A few examples of these bodies are cited to illustrate their peculiar characters.

(A) *Embedded in the stroma of the culture medium.*

(*a*) Spherical, internal diameter 175μ, wall 35μ thick; hyphae inside the wall, loose, hyaline and light-brown.

(*b*) Nearly spherical, internal diameter 185μ, wall 28μ thick; internal hyphae faintly brown and hyaline.

(B) *On the stroma of the culture medium.*

(*a*) Globose, partly embedded, diameter about 210μ, wall 25μ thick; within, light-brown hyphae radiate from one side and grow out to the exterior forming a mass of aggregated brown mycelium on which conidiophores are produced.

(*b*) Irregular in shape, greatest width 0·82 mm.: greatest height 0.56 mm.; wall about 17μ thick; within the hyphae are hyaline, light-brown and loose and continue their growth to the outside, through one side of the wall at the top, forming a mass of brown pseudoparenchymatous tissue from which setae and conidiophores radiate in the shape of an open fan.

The fungus was also grown on French bean agar and on this medium also perithecia did not develop. Similar black bodies as formed on maize-meal agar were produced. The mode of growth of the hyphae was somewhat similar except that it was more fluffy. The conidiophores attained a length of 60μ and the conidia measured 12-21 × 4-6μ with a mean (50 spores) of 16·62 × 5μ.

Seventeen inoculations were made on chilli fruits and twelve were successful; five inoculations were made after wounding and all were suc-

cessful. No perithecial stage was formed. On chilli fruits in Roux tubes sterilised by dipping in boiling water and on sterilised potato slab, the perithecial stage was not produced.

This fungus is no doubt *Colletotrichum nigrum* E. and Halst., but it does not produce a perithecial stage in nature, in culture or on inoculated chilli fruits. The small black bodies which are formed in the culture media and which possess walls appear to be attempts on the part of the fungus to produce perithecia.

GLOEOSPORIUM PIPERATUM E. AND E.

A *Gloeosporium* was found attacking ripe chilli fruits in the field. The disease usually appears on the fruit as minute black or yellowish sunken spots which gradually extend, turning the skin a dirty-brown colour. The symptoms and microscopic characters of the disease are practically identical with those of *Colletotrichum nigrum*, except that the acervuli of the *Gloeosporium* are devoid of setae. Cream-coloured and pale-pink pustules of spores develop freely on the diseased tissue ; full-grown fruits still green, are also subject to attack. The affected area turns dirty-brown and becomes sunken and fructifications in the form of small black points spread round the sunken spot very often in concentric zones. The conidiophores are up to 27μ long and 2-3μ diameter ; the conidia 11-24 × 4-6μ with a mean (50 spores) of 15·76 × 4·7μ. No perithecial stage was associated with the fungus.

The conidia germinate in water in about five hours and the germ-tubes frequently anastomose. A conidium may produce a germ-tube which is capable of producing another conidium and this conidium could produce another germ-tube which in turn can give rise to another conidium and so on. The germ-tubes do not form appressoria. In standard nutrient solution the spore behaves in a similar manner.

Single spore cultures were obtained and transferred to maize-meal agar slants. The mode of growth was similar to that of *Colletotrichum nigrum*. The conidiophores were up to 50μ long and 2-3·5μ diameter ; the conidia 11-20 × 4-6μ with a mean (50 spores) of 15 × 4·6μ. No setae developed in culture and perithecia were not produced, but instead small black bodies with distinct dark-brown walls similar to those found in the non-perithecial strain of *Colletotrichum nigrum* were present, having practically identical characteristics. When the fungus was grown on Raulin neutral agar and French bean agar, the behaviour was similar to that on maize.

Fourteen inoculations were made on green fruits and eleven were successful ; four inoculations on ripe fruits and three were successful.

No perithecial stage was obtained. On chilli fruits sterilised by boiling in Roux tubes and on sterilised potato slab no perfect stage developed.

Comparing the dimensions of the spores with that given for *Gloeosporium piperatum*, the two fungi are apparently the same. The perfect stage of *Gloeosporium piperatum* is said to be *Glomerella piperata* (Stonem.) S. and v. S., but it was not found in nature on chilli fruits in Peradeniya, nor could it be obtained in culture. The small black bodies found in culture appear to be attempts at perithecial formation.

VERMICULARIA CAPSICI SYD.

The first symptom of the disease is a slight depression dirty-brown in colour on the surface of the fruit. This dirty-brown colour gradually extends generally longitudinally along the fruit towards the lower end. The affected area turns dry and black fruiting bodies soon appear on the dry area, either irregularly or in concentric zones. With the formation of fructifications the skin shrivels and becomes wrinkled. Spores ooze out from the black bodies in pale pink pustules. With the aid of a hand lens, black, bristly hairs are visible in the fruiting masses. The fruit stalk too gets affected and gradually the fungus enters the branches and kills them back. Diseased fruits are frequently seen hanging on the bush for a considerable time, but sometimes they drop to the ground.

The fungus is a *Vermicularia*. The tubercular stromatic masses measure 70-140μ diameter. From the surface of the tubercular masses, closely crowded hyaline stalks arise appearing yellowish in mass. These are the condiophores which are non-septate and unbranched and are usually of the same length as the spores they bear, varying in length from 12-27μ and in diameter from 2-4μ. The setae are dark-brown, stiff, rigid, erect, septate, acute and paler at the apex, up to 210μ long and 4-6μ diameter. The conidia are pinkish in mass, hyaline, non-septate, curved, narrowed at the ends, 15-28 × 2·5-4μ with a mean (50 spores) of 23·3 × 3·5μ.

On the inner surface of the skin of the fruit small, black, round, pseudoparenchymatous bodies are found. Some bodies are bounded by a layer of dark-brown, thick-walled cells forming a wall about 12-17μ thick in different bodies, while the central cells are loose, hyaline or faintly brown. These bodies are almost spherical in shape and vary in diameter from 70-140μ.

The fungus also attacks the seeds. The hyphae inside the seed are hyaline and turn brown when they collect into masses.

Cultures

Single spore cultures were made from conidia ; they were germinated in water and also grown on maize-meal agar and French-bean agar to see whether the perfect stage would develop in culture.

Germination in water. A series of drop cultures was made in ordinary tap water and examined from time to time. In a culture five hours old few spores had germinated, sending out short, hyaline germ-tubes from near the ends up to 25μ in length and 1·5-2μ diameter. Nearly all the germinated spores had a spherical swelling, hyaline and thin-walled at the end of the germ-tubes. These terminal swellings are immature appressoria. Some germinated spores had become bicellular by a septum being formed near the middle of the spore. In a culture seventeen hours old practically all the spores had germinated and were bearing appressoria at the end of short germ-tubes. A germ-tube rarely reaches a length of 60-80μ before the appressorium is formed. The appressoria which were hyaline and thin-walled at first are now thick-walled and dark-brown, spherical, oblong-oval or globose, varying in diameter up to 5μ. An appressorium may germinate and form another appressorium at the end of a short germ-tube. The majority of the germinated spores have a septum. In a culture twenty-four hours old, spores were found having very long germ-tubes and terminating growth in appressoria and these appressoria germinating again and continuing vegetative growth. Some spores were found having two germ-tubes, one at each end.

Maize-meal agar. The slants were inoculated with spores from a pure culture. On the third day white floccose hyphae had grown one centimetre from the point of inoculation on the surface of the medium. On the following day small raised black bodies appeared on the surface and a few were embedded in the culture medium. At the sides, where the culture medium meets the glass, very small black bodies were found. By the seventh day growth had extended to three centimetres and was aerial, woolly, and greyish-white in mass. A large number of the black bodies found in the medium were producing spores, pale-buff in mass. Aerial growth now ceases altogether and the fungus confines itself to the medium. In old cultures, a distinct margin is formed, of black stromatic tissue at the sides. In some old cultures instead of the fructifications appearing as buff-coloured pustules, they appear as rough, black, bristly heads.

Microscopic examination. The hyphae which appear greyish-white in mass are loose and hyaline. Hyphae 6-8μ diameter had branches 2-3μ diameter and spores were produced at the end of these branches.

In microtome sections a pseudoparenchymatous stroma consisting of closely interlaced brown mycelium is found in the culture medium

up to about 0.92 mm. deep. The black bodies producing spores are stromatic masses, made up of closely interlaced brown mycelium. They are of various shapes, being usually pulvinate, cup-shaped or spherical and with a diameter up to about 0·56 mm. They occur singly or clustered together, and sometimes covered with a thin film of brown hyphae. The black bodies which did not produce spores and appear like sclerotia are simply masses of brown hyphae aggregated together. They are spherical or nearly spherical in shape, varying in diameter up to about 140μ and are found in the culture medium and in the pseudostroma formed in the medium. The black band at the sides of the culture medium is composed of stromatic tissue formed by hyphae producing appressoria which run into chains.

Setae and conidiophores arise from the surface of the stromatic masses. The former are dark-brown, rigid, septate, and slightly swollen at the base, paler at the apex and varying in length up to 280μ, and in diameter up to 6μ. The latter are similar to those found in nature. The conidia are hyaline, non-septate, curved, narrowed at the ends, and measure 15-30×3-4μ with a mean (50 spores) of 22·5×3·6μ.

French-bean agar. The slants were inoculated with spores from a pure culture. On the third day white floccose hyphae had grown about eight millimetres distant from the point of inoculation. From the fifth day onwards hyphae grow confined to the surface of the medium and fructifications buff colour and black in mass begin to be formed. After the seventh day no hyphal growth is visible on the surface of the culture medium and fructifications increase in number. At the edges when the medium meets the glass a black band of stromatic tissue is formed. In old cultures the surface of the medium is covered with black fructifications in the form of bristly heads.

Microscopic examination. The loose floccose hyphae very frequently produce spores at the ends of their branches. Certain cells of the hyphae swell out, gradually turn brown and are capable of giving out a hyaline hypha. These are intercalary chlamydospores. The black band of stromatic tissue at the edges of the culture medium is composed of chains of appressoria.

In microtome sections a pseudoparenchymatous stroma varying in depth up to about 1·38 mm. made up of interlaced brown and hyaline hyphae is found in the culture medium. Spores are produced from stromatic masses. These masses are of various shapes being usually cup-shaped, pulvinate or tubercular occurring singly or aggregated and varying in diameter up to about 0·78 mm. The outer portion of these masses is composed of darker-brown cells and it is from these cells that setae and conidiophores arise. The cells within the tubercle are hyaline

and faintly-yellowish in colour. Small black bodies, spherical or globose in shape, are found in the film of mycelium on the culture medium, on the stroma in the medium or attached to stromatic masses producing spores. They are composed more or less uniformly of brown cells, and vary in diameter up to 280μ. In some bodies a wall about 15μ thick is found consisting of darker-coloured cells. Within the wall the hyphae are hyaline or faintly-brown. The setae and conidiophores arise from the surface of the stromatic masses. The former vary in length up to 380μ and in diameter at the base up to 8μ. The conidiophores are of the same dimensions as in nature. The conidia measure 20-32 × 2·5-4μ, with a mean (50 spores) of 26·5 × 3·5μ.

The *Vermicularia* found on chilli is *Vermicularia Capsici* Syd., but no perfect stage is found in nature or in culture.

Inoculations

Experiment 1. On chilli fruits in the field. Five inoculations were made on four green and one ripe fruit by placing small pieces of a pure culture on maize-meal agar on the surface of the fruits, covering the inoculum with a piece of sterilised cotton wool and wetting the whole with distilled water. The cotton wool was wetted daily. On the sixth day a slight discolouration was visible round the inoculated spots of three fruits. The cotton wool was removed and the fruits exposed. On the tenth day fructifications developed. After a fortnight these fruits were plucked and examined. The skin over the affected area was quite dry and leathery, not sodden. The seeds were enveloped in a greyish mycelium. Two of these fruits were left in a sterile petri-dish for over a month and examined from time to time, but no perfect stage was found. Two green fruits failed to take infection. Three fruits were left as a control on the same bush, a small piece of cotton wool being placed on them and wetted daily for six days, but no disease developed in them.

Three inoculations were tried on green fruits after wounding and these developed the disease within four days.

Experiment 2. On chilli fruits in sterile test-tubes. Three green and one ripe fruit was washed in ·1 per cent. Corrosive Sublimate for ten minutes, then in distilled water, put into sterile test-tubes and inoculated with spores from a pure culture. After six days one green fruit began to discolour turning dirty-green at the lower end of the fruit, although the inoculum was placed near the stalk end of the fruit, which spot was yet not discoloured. This may have been due to the spores running down the fruit to the bottom, mixing with the little water that was present at the lower end of the test-tube and infecting the fruit from there

Five days later black fructifications were found in abundance at the lower end of the fruit and gradually extended upwards. The three other fruits began to discolour at the inoculated spot on the fifth day and ten days later black fruiting bodies began to appear round the inoculated area. No aerial hyphae were found. Two fruits which were kept as a control in sterile test-tubes remained unaffected during the period of the experiment.

Experiment 3. On chilli fruits in a moist chamber. (*a*) Four green and two ripe fruits were sterilised as in Experiment 2, placed in a moist chamber and inoculated with spores. The spores were mixed in sterile water and two drops were placed on each fruit. Four days later three green and one ripe fruit turned pale in colour and soft to the touch. On the eighth day white fluffy hyphae overran the surface and on the eleventh day fructifications began to be formed plentifully. On the other green fruits discolouration appeared on the sixth day and fructifications developed on the eleventh day ; no external hyphae were found and the fruit did not become soft. The other ripe fruit did not develop the disease. One ripe and one green fruit were kept as a control in the same moist chamber, but remained unaffected during the experiment. (*b*) Two green and two ripe fruits were inoculated in a similar manner to the above, but after wounding with pin-pricks. Infection took readily, discolouration was visible in three days and in six to eight days fructifications developed. The fruits became quite sodden and spores appeared in dirty white and cream-coloured pustules.

Experiment 4. On chilli fruits sterilised by dipping in boiling water. Four green fruits were sterilised, put into Roux tubes and inoculated with spores. On the fifth day the surface of the fruits was covered with black fructifications. Aerial growth of white hyphae was present, but was hardly noticeable.

Experiment 5. On sterilised potato slab. The fungus grew profusely on the potato slab and produced a copious mass of white hyphae on the surface. When examined two months later the hyphae had disappeared and a black stroma was found on the surface and abundant masses of sclerotium-like bodies were formed in this stroma. These masses were made up of hyphae, brown in colour, closely aggregated together. No spores were produced.

Eleven inoculations were made on green fruits and nine were sucessful ; four on ripe fruits and three were successful. Five inoculations were made on green fruits and two on ripe fruits after wounding, and all were successful. No perfect stage was found.

On sterilised potato slab and on sterilised chilli fruits no perithecia developed.

SUMMARY

1. Three fungi are found on chilli fruits in nature in Ceylon,—a *Vermicularia*, a *Colletotrichum* and a *Gloeosporium*, and they have been identified as *Vermicularia Capsici*, *Colletotrichum nigrum* and *Gloeosporium piperatum*.

2. Two strains of *Colletotrichum* occur—one, a perithecial strain and the other a non-perithecial strain ; the perfect stage of the perithecial strain is identified as *Glomerella piperata*.

3. The perfect stage of *Gloeosporium piperatum* was not found in nature on the fruit, nor could it be obtained in culture. In the United States it has been identified as *Glomerella piperata*. At Pusa, India, it is found on the plant and in culture.

4. If it is established that the perfect stage of *Gloeosporium piperatum* is *Glomerella piperata*, then the Ceylon *Gloeosporium* which has not been found to produce perithecia and the Ceylon *Colletotrichum* which produces a perithecial stage, are both the same fungus. But the cultures described in this paper do not provide any evidence on that point.

5. The formation of setae of *Colletotrichum nigrum* in culture is not a constant feature. They may occur in acervuli in one part of the culture medium whereas in other parts of the same culture medium they are absent.

6. It is of interest to note that a large number of conidia of both the strains of *Colletotrichum nigrum* produce appressoria at the end of germ-tubes when sown in water, but the conidia of *Gloeosporium piperatum* do not form appressoria.

7. The perfect stage of *Vermicularia Capsici* has not been found.

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LITERATURE CITED

Butler, E. J. Fungi and Disease in Plants, pp. 352-357.

Dastur, J. F. Die-Back of Chillies (*Capsicum* spp.) in Bihar, Mem. Dept. Agric. India, Bot. Ser., XI, pp.129-144.

Saccardo, P. A. Sylloge Fungorum, Vol. XXII. B, p.1203 (*Colletotrichum nigrum* Ell. et Halst.) Vol. XVI, p. 453 (*Gnomoniopsis piperata* Stonem.)

Shear, C. L. and Wood, Anna K. Ascogenous Forms of *Gloeosporium* and *Colletotrichum*. Bot. Gazette, Vol. XLIII, pp.259-266 (1907).

EXPLANATION OF PLATES

Plate XIV

Figs. 1, 2, 3. Conidia germinating in water and forming appressoria. × 950.

Fig. 4. Conidium producing an intercalary chlamydospore. × 950.

Figs. 5, 6, 7. Asci. × 950.

Figs. 8, 9. Ascospores budding off secondary conidia. × 950.

Fig. 10. Ascospore germinating in water and forming conidia at the end of lateral branches. × 950.

Fig. 11. Ascospore germinating at both ends. × 950.

Figs. 12, 13, 14. Ascospores germinating in water and forming appressoria. × 950.

Fig. 15. Ascospore in water, producing a germ-tube at one end and budding off a secondary conidium at the other end. × 950.

Plate XV

Fig. 1. Vertical section of a globose perithecium with conical apex. × 270.

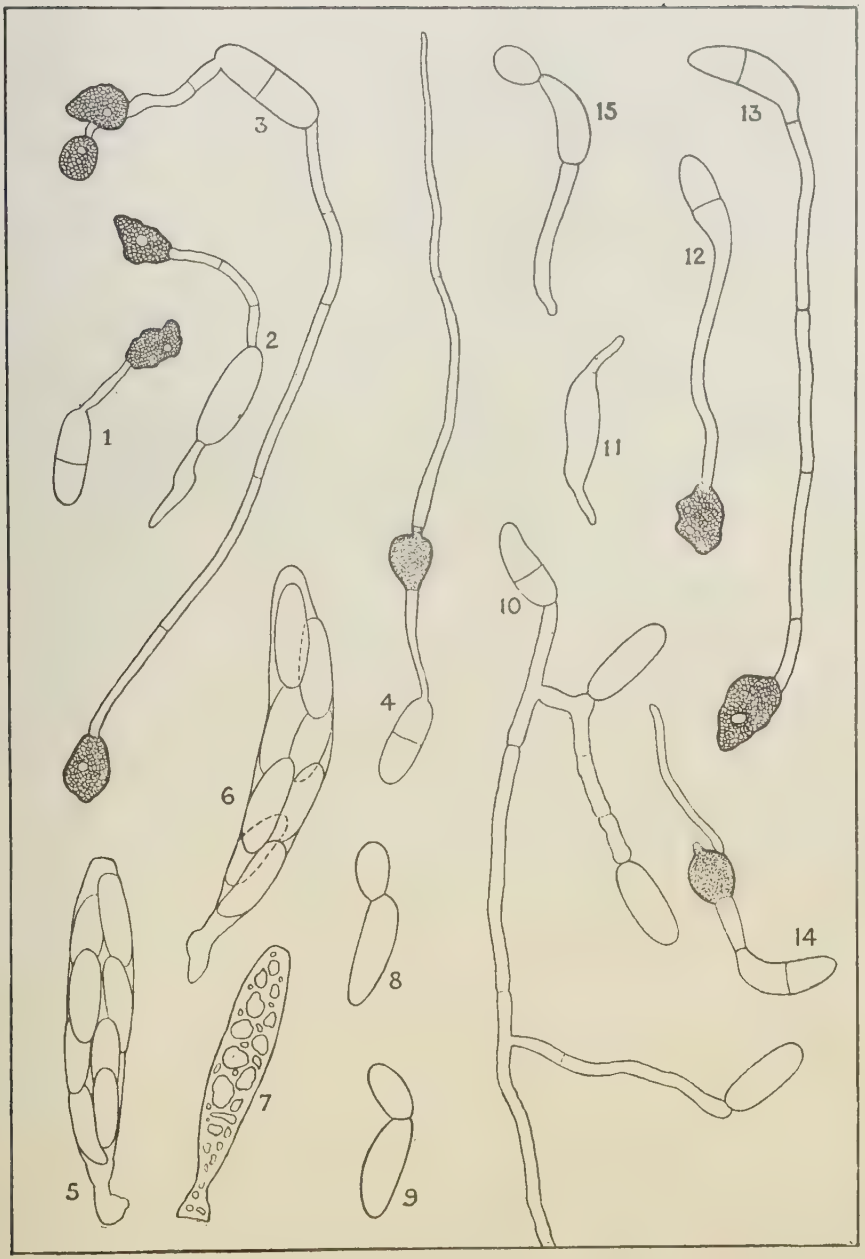
Fig. 2. Vertical section of a flask-shaped perithecium fused with another perithecium. × 230.

Fig. 3. Vertical section of two conoid perithecia × 228.

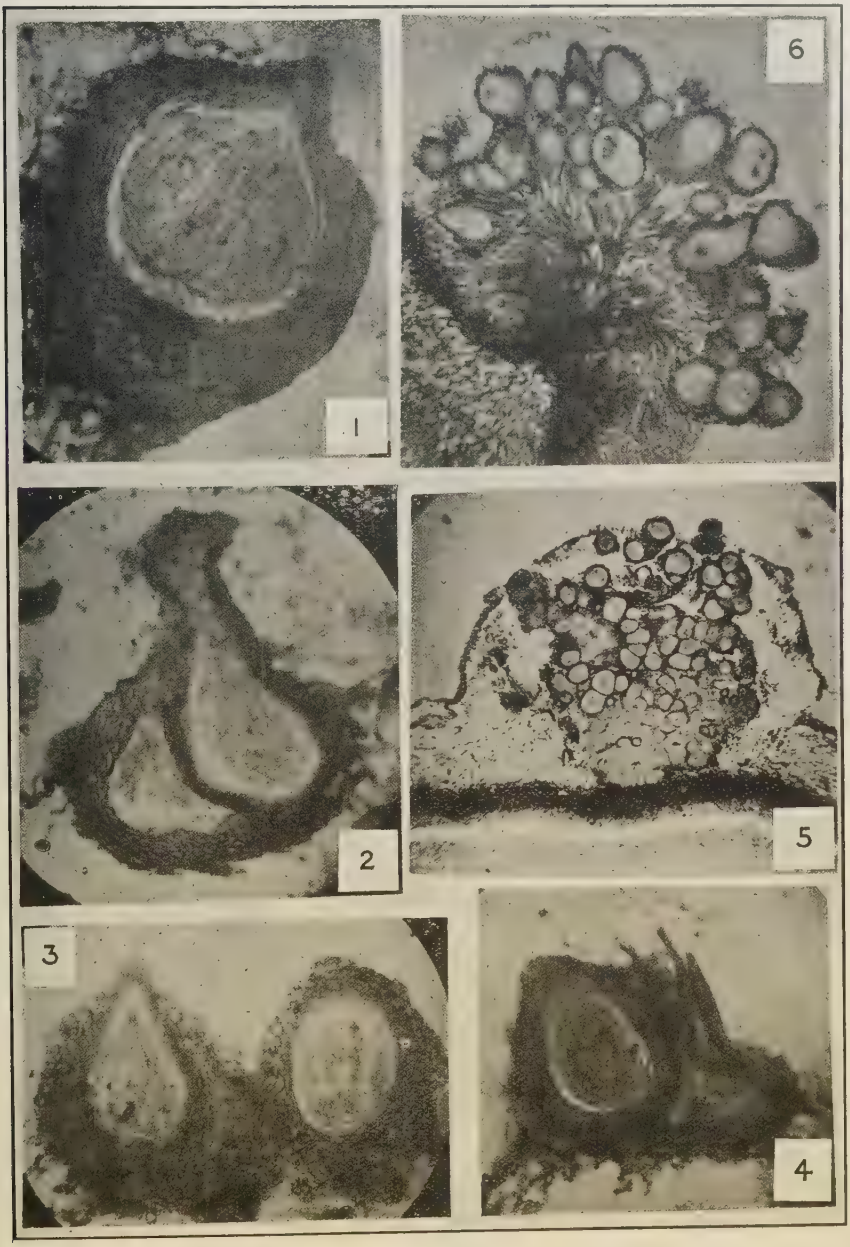
Fig. 4. Vertical section of a conoid perithecium attached to an acervulus. × 235.

Fig. 5. Vertical section of a pulvinate mass, composed of numerous perithecia and loculi formed in culture. × 26. Original culture from a single ascospore.

Fig. 6. Vertical section of a normal acervulus producing perithecia in culture. × 52. Original culture from a single conidium.



Bertus—Diseases of Chillies



Bertus—Diseases of Chillies

Notes on some Symplocaceae of Ceylon

BY

E. J. Livera, B. Sc. (Lond.)

Assistant in Systematic Botany, Department of Agriculture, Ceylon

Brand (2) who treats the species of *Symplocos* as a separate order, includes *S. versicolor* Clarke under *S. spicata* Roxb., stating (p. 40) " Haec species valde variabilis a cl. A. DC., Clarke aliisque in multas varietates divisa est. Sed. inter has varietates tam multae formae intermediae occurrunt, ut melius esse videatur varietates bene circumscriptas non constituere." In the course of his description of *S. spicata* Roxb., drawn up from the several specimens examined by him, he says (I) " folia serrata vel subintegra, utrinque acuta " (II) " Fructus c. 5 mm. longus." He makes a new var. β *acuminata*—" Folia longe acuminata," and on pp. 32 and 33 in his key, he credits *S. spicata* with " Inflorescentiae semper vel partim compositae."

Now *S. versicolor* Clarke has (I) entire very faintly crenate margins, (II) Fruit 1.3 cm. long, (III) a caudate-acuminate leaf which does not resemble that of *S. spicata* var *acuminata* Brand., (IV) a simple inflorescence (compare Trimen's key (1) p. 103). The other points of difference are tabulated below.—

	S. versicolor	*S. spicata*
1.	Petiole thin and slender.	Petiole stout.
2.	Flowers few on each inflorescence.	Flowers numerous on each inflorescence.
3.	Inflorescence 2·5-3·8 cm. long.	Inflorescence 5·1-7·6 cm. long.
4.	Calyx segments ciliated.	Calyx segments not ciliated.
5.	Drupe linear-oblong, 1·3 cm.	Drupe urceolate, short, 0·5 cm.
6.	Seed and embryo straight.	Seed and embryo curved.

In view of these ten points of difference *S. versicolor* Clarke should be maintained as a distinct species.

Symplocos obtusa var. ⊁ **obovata** Thw.

Trimen (1) p. 105 made the following note on this variety: "var. ⊁. looks very different, and is perhaps distinct as a species." Brand had not seen specimens of this plant, which has indistinctly pentadelphous stamens, filiform filaments, a trilocular ovary with a glabrous style, seeds and embryo straight. According to the various keys given by Brand (2), based on the 281 species he examined, this specimen comes under subgenus *Hopea* (L.f.) Clarke, Section *Bobea*, subsect. *Lodhra*, which includes one hundred and twenty-two species. *S. furcata* Brand (*S. obtusa* Thw.) is the 44th of this group and *S. obtusa* var. *obovata* works down to between the 92nd *S. buxifolia* Stapf, and the 93rd, *S. anamallayana* Bedd. from both of which it differs abundantly. Furthermore, Brand (2, p. 57) describes *S. furcata* (*S. obtusa* Thw.) as having (I) " Folia 4-6 cm. longa, 2-3 cm. lata," (II) " Corolla 6-vel 7-partita," (III) " Fructus c.10 mm. longus ;" and (IV) In his keys, pp. 42-48, he attributes to *S. furcata* (*S. obtusa* Thw.) an inflorescence of 4-numerous flowers. *S. obtusa* var. *obovata* Thw. has (I) Leaves 2·5-3·5 cm. long, 2-2·5 cm. broad.(II) Corolla 5-partite.(III) Fruit 1·3 cm. long.(IV)Solitary and axillary flowers. The other points of difference are shewn in the following table.—

	S. furcata (*S. obtusa* Thw.)	*S. obtusa* var. *obovata*.
1.	Leaves oval or obovate-oblong.	Leaves broadly obovate or sub orbicular.
2.	Leaf apex obtuse or shortly acuminate.	Leaf apex obtuse or retuse.
3.	Leaf margins glandular denticulate, or serrate, faintly revolute.	Leaf margins entire, distinctly revolute.
4.	Flowers sessile except at the base of the inflorescence.	Flowers distinctly long-stalked.
5.	Flowers 1-1·25 cm. across.	Flowers 0·75 cm. across.
6.	Calyx segments round, ciliate.	Calyx segments triangular with acute apices.
7.	Corolla 6-7 segments.	Corolla 5-segments.
8.	Drupe oblong-ovoid.	Drupe narrow, cylindrical.

In view of all these differences this variety is entitled to specific rank.

S. obovata (Thw.) Wight and Gardner MSS. in Thw, Enum. Pl. Zeyl. (1860) p. 185. *S. obtusa* Wall var. *obovata* Thw., Enum., (1860) p. 185, Trimen, Fl. Ceylon, III (1895) p. 105 C.P. 1819.

Arbor glaber. Folia 2.5-3.5 cm. longa, 2-2.5 cm. lata, coriacea, glabra late obovata vel suborbicularia, apice obtusa vel retusa, basi cuneata integra, breviter petiolata. Flores solitarii in axillis foliorum summorum. Pedunculi petiolo 2-3-plo longiores; bracteae obovatae; calyx glaber, lobis triangularibus tubo brevioribus; stamina c. 40; ovarium glabrum. Fructus 1.3 cm. longus, oblongo-cylindricus, lobis discum superantibus.

Endemic. Upper Montane Zone; common. Pidurutalagala, Pallagalla. Flowers April.

S. eugenioides (Champ.)

Trimen (1) p. 109 says in a note on *S. minor* "I cannot distinguish var. *eugenioides* Champ. (Fl. B. Ind.), from var. *glabrescens*. The leaves are often cucullate. If we are to accept Brand (2, p. 64) who gives *S. glabrescens* specific rank, then, according to Trimen, *S. minor* var. *eugenioides* is the same as *S. glabrescens*. But according to Brand's definition, *S. glabrescens* has (1) Folia 3-4 cm. longa, 2-3. cm. lata, (2) Spicae pilosae 2-3 florae, (3) Spicae petiolo 2-3-plo longiores, (4) Stamina ultra 30, (5) Ovarium brevissime pilosum, (6) Fructus 12 mm. longus. *S. minor* var. *eugenioides* has (1) Leaves 4-6·5 cm. long, 3·2-4 cm. broad, (2) Spike villose 4-flowered, (3) Spike 1½ times longer than the petiole. (4) Stamens about 60, (5) Ovary glabrous, (6) Fruit 15 mm. long. *S. minor* var. *eugenioides* also differs in having entire leaf margins instead of serrated margins.

On the other hand, we find that *S. minor* differs from *S. minor* var. *eugenioides* in the points shewn in the following table:—

	S. minor	var. *eugenioides*
1.	Branches hirsute all over.	Branches very slightly pubescent with adpressed hairs only at the extreme apex.
2.	Leaves small, 3-4 cm. long, 2-2·5 cm. broad.	Leaves large 4-7·5 cm. long. 3·2-4 cm. broad.
3.	Leaves with many long bristles on the lower surface.	Leaves sparingly hairy on the midrib on the lower surface.
4.	Leaf margins denticulate serrate, revolute.	Leaf margins entire, not revolute.

5.	Petals nearly 0·5 cm.long, densely hirsute.	Petals 1 cm. long, glabrous.
6.	Racemes 2·5 cm. long.	Racemes 1·5 cm. long.
7.	Corolla 6 partite.	Corolla 5 partite.
8.	Fruit 10 mm. long.	Fruit 15 mm. long.

S. eugenioides is therefore entitled to specific rank.

S. eugenioides (Champ.) Livera sp. nov. *S. minor* Clarke var. *eugenioides* Champ. ex Clarke in Hook. f. Flora British India III (1882) 586.

Frutex initio villosus mox glaber. Folia coriacea 4-7·5 cm. longa, 3·2-4 cm. lata, elliptica, supra glabra, subtus breviuscule pilosa ad nervos, acuminata, subserrulata, basi rotundata. Spicae villosae 2-4 florae, petiolo 1·5-4 plo longiores, pilis brevibus densae vestitae ; bracteae oblongo-lineares ; calyx glaber, lobis rotundatis tubo subaequantibus vel longioribus ; corolla calyce 2·5-3 plo. longior, 5-partita. Stamina circiter 60 ; ovarium glabrum. Fructus 1·5 mm. longus, nitidus, glaber, cylindricus, apice paullo angustatus.

Endemic. Horton Plains and Namunukulakanda.

The older part of the branches is quite glabrous. Leaves acute acuminate, shortly and distantly serrate : veins prominent. Inflorescence axillary, densely villous. Bracts and bracteoles subsimilar, densely villose on outer surface only. Flowers sessile ; sepals oblong-obtuse, glabrous. Corolla 0·5 cm. long, petals obtuse, stamens indistinctly pentadelphous. Disc villous. Style glabrous.

Brand separates a new species *S. amabilis* (p. 63) from *S. elegans* Thw. His description of *S. amabilis* applies to Thwaites' type specimens of *S. elegans* with the exceptions (I) Folia crasse coriacea, (II) Pedunculi ferruginei petiolo brevissimo 3-4-plo longiores. With dried specimens one cannot with certainty say whether leaves are thinly or thickly coriaceous. There are peduncles of *S. elegans* which are even ten times longer than the petioles and these may include *S. amabilis*. The differences between *S. elegans* Thw. and *S. amabilis* as Brand gives them are tabulated below :—

	S. elegans.	*S. amabilis.*
1.	Ramulis hirsutis.	Splendide ferrugineis.
2.	Folia 5-6 cm. longa, 1·5-2·5 cm. lata.	3-5 cm. longa, 1·5-2·5 cm. lata.
3.	Stamina 60-80.	Ultra 30.
4.	Ovarium brevissime pilosum.	Glabrum.
5.	Inflorescentiae 4-numerosae florae.	1-3 florae.

1. In the harbarium specimens of *S. elegans*, all stages between "hirsutis" and "splendide ferrugineis are found."

2. All Thwaites' type specimens of *S. elegans* (with the exception of one, in fruit—which has leaves 6 cm. long) have leaves under 5 cm.; moreover, the difference between the maximum lengths of the leaves of the two species is only 1 cm. 3. Some type specimens of *S. elegans* have the number of stamens varying between 30 and 60 and inflorescences of less than four flowers. Therefore, the only difference between the two species is in the ovaries and this is a slight one. *S. amabilis* Brand cannot therefore be maintained as a distinct species.

REFERENCES

(1) Trimen, H. Flora of Ceylon, III pp. 103-109, (1895).
(2) Brand, A. in Engler's Pflanzenreich, 6 Heft. (1901).

INDEX

PAGE

A.

Acanthaceae .. 29
Acanthaceae, Altitudinal range of 29
Acmonorhyncus vincens .. 34
Acrotrema, Distribution of seeds by caterpillars .. 8
Actinostilbe Vanillae Petch 195
Additions to Ceylon Fungi, IV 131
Adinandra lasiopetala, fruit eaten by Mynas .. 9
Aecidium Chionanthi B. & Br. 166
Aegerita candida P. .. 168
A. discordea Petch .. 168
A. mellea B. & Br. .. 176
Aeginetia Linn 147, 154
A. abbreviata Ham. .. 150,155
A. acaulis Wall. 150,155
A. Centronia Miq. .. 155
A. indica Linn. 154
A. mirabilis Livera .. 150,155
A. pedunculata Trim. .. 155
A. pedunculata Wall. .. 155
A. Rodgeri Livera .. 155
A. Saulierei Livera .. 155
A. Scortechinii Livera .. 156
A. siamensis Livera .. 155
A. subacaulis Livera .. 155
A. Trimenii Livera .. 149,155
A. Wightii Livera .. 156
Aeginetiaceae 145
Aeschynanthus zeylanica .. 28
Aglaia apiocarpa .. 15
Alangium glandulosum .. 21
Alectra Thunb. 146
Allaeanthus 36
Allophylus hispidus .. 16
Altitudinal Distribution of the Ceylon Endemic Flora, The 1
Alyxia ceylanica Wight .. 140
A. zeylanica 25
Amarantaceae 31
Ampelideae 16
Anamirta Cocculus W. & A., Cladosporium herbarum var. torulosum B. & Br. on 172
Anarrhinum Desf. .. 146
Anacardiaceae 16
Ancistrocladus Vahlii .. 12
Anisophyllea zeylanica 19
Anodendron rhinosporum .. 25
Anonaceae 8

PAGE

Anthina cinnabarina B. & Br. 178
Apocynaceae 24
Apodytes Gardneriana .. 15
Aponogeton crispum .. 40
Araceae 40
Araliaceae 21
Ardisia 23
Areca Catechu, Exosporium Arecae Petch on .. 173
A. Catechu 39
A. concinna 39
Artocarpus integra Merr., Mycena farinosa Petch on 132
A. integrifolia 36
A. nobilis 36
Asclepiadaceae 8,25
Asclepiadaceae, Altitudinal range of 26
Asparagus zeylanicus .. 38
Avicennia officinalis .. 30

B.

Baissea acuminata .. 25
Balanocarpus zeylanicus .. 11
Balanophoraceae .. 35
Barringtonia zeylanica .. 19
Basidiomycetae .. 131
Bassia neriifolia. .. 23
Biophytum nervifolium .. 13
B. nudum 14
B. proliferum 14
Bixaceae 9
Boraginaceae 27
Botryosphaeria Vanillae Petch & Rag. 191
Bulbophyllum maskeliyense Livera 142
Burmannia Championii .. 36
Burmanniaceae .. 36
Burseraceae 14
Buttonia McKen .. 146

C.

Calamus 39
Callicarpa indica .. 30
Calophyllum from Degalhella 7
Calophyllum, seeds animal carried 9
Calospora Vanillae Massee 181, 182, 187, 191
Camellia theifera Dyer, Diatrype conferta Petch on 136

PAGE

C. theifera Dyer, Helminthosporium gigasporum B. & Br. on 173
C. theifera Dyer, Leptosphaeria depressa Petch on 135
Cameraria zeylanica Retz.. . 142
Campanella purpureobrunnea Petch 133
Campbellia Wight .. 153, 158
C. citinoides Wight .. 158
C. subacaulis Benth. .. 155
Canarium brunneum .. 14
C.zeylanicum 15
Campnospermum zeylanicum 16
Capparideae 9
Carallia calycina .. 19
Carex lobulirostris .. 41
Caryophyllaceae .. 9
Caryota urens 39
Celastraceae 15
Ceylon Fungi, Additions to 131
Ceylon Fungi, Revisions of, Part VIII. 161
Ceylon, Vanilla disease in .. 185
Centranthera R. Br. .. 146
Centronia Blume .. 154
C. mirabilis Blume .. 155
Centronota DC. .. 154
C. mirabilis DC. .. 155
Cercosporella Crataevae Petch 171
Championia reticulata .. 28
Chena Cultivation, affect in vegetation .. 5
Chillies, Fruit diseases of .. 295
Chirita Moonii 28
C. zeylanica 28
Chiristisonia Gardn. 147, 150, 156
C. albida Thw. 158
C. albida Trim. 157
C. aurantiaca Wt. 152, 157
C. bicolor Gardn. .. 157
C. bicolor var. pallidiflora Thw. 157
C. bicolor var. pallida Livera 157
C. bicolor var. spectabilis Trim. 157
C. calcarata Wt. .. 186
C. grandiflora Gardn. .. 151, 156
C. Hookeri Clarke .. 156
C. Lawii Wight 156
C. neilgherrica Gardn. .. 158
C. pallida Gardn. .. 151
C. Rodgeri Smith and Banerji 156
C. Saulierei Dunn .. 155
C. Scortechinii Prain .. 156
C. siamensis Craib .. 155
C. spectabilis Thw. .. 152, 157
C. Stocksii Hook .. 156
C. subacaulis Gardn. . 148, 149, 155
C. Thwaitesii Trim. .. 156
C. tricolor Gardn. .. 156
C. tubulosa Benth. .. 156
C. unicolor Gardn. .. 152, 157
C. Wightii Elmer .. 156
C. zeylanica Livera .. 152

PAGE

Cinnamomum Camphora T. Nees and Eberm. Rosellinia caudata Petch on .. 135
C. Camphora T. Nees and Eberm, Rosellinia decidua Petch on 136
C. Camphora T. Nees and Eberm, Rosellinia obtusa Petch on 136
Citrus decumana, Coremium compressum Petch on .. 176
Cladosporium herbarum var. torulosum B. & Br. .. 172
Cliffordia Livera .. 151, 156
C. aurantiaca Livera .. 157
C. bicolor Livera .. 157
C. spectabilis Livera .. 157
C. unicolor Livera .. 157
C. zeylanica Livera .. 157
Clitocybe corrugata Petch .. 131
C. flavescens Petch .. 131
Clonostachys pulvinata Petch 176
Coconut, Grey Blight of Tea and 197
Colletotrichum on Vanilla 182, 183, 184, 187
C. nigrum E. & Halst .. 296
C. Vanillae Scalia 183, 184, 191
Collybia multijuga B. & Br. 131
Combretaceae 19
Commelinaceae 38
Commelina Thwaitesii .. 38
Compositae 22
Compositae, Altitudinal range of 26
Connaraceae 17
Connarus Championii .. 17
Convoloulaceae 27, 8
Coprinus castaneus B. & Br. 166
C. macrorhizus Rea .. 133
C. setulosus B. & Br. .. 165
Cordyceps coccinea Penz. and Sacc. 178
Cornaceae 21
Crataeva Roxburghii, Cerios-porella Crataevae Petch on 171
Crepidotus epicrocinus B. & Br. 164
Cucurbitaceae 20
Curcuma domestica var. purpurea Livera .. 143
C. domestica Val. .. 143
Cuscuta 27
Cyanotis obtusa .. 38
C. zeylanica 38
Cycnium tubulatum Benth 146
Cyperaceae 40
Cyperaceae, Altitudinal range of 42
Cystospora Oleae Butl. .. 166
Cytospora on Vanilla 181, 184, 192

D.

Dadap (Erythrina lithosperma), A Fusarium disease of .. 275
Dasyscypha hylina P. .. 168

PAGE

Debregeasia 36
Diatrype conferta Petch .. 136
Dicaeum erythrorhyncum .. 34
Dicellostyles axillaris .. 13
Dicaeum feeding on Medinilla 20
Didymobotryum rigidum Sacc. 169
D. atrum Pat. 169
Didymocarpus Humboldtianus 28
D. zeylanicus 28
Dillenia retusa, Distribution of seeds by animals .. 8
Dilleniaceae 7
Dioscorea intermedia .. 38
Dioscoreaceae 38
Diospyros attenuata .. 23
D. Gardneri 24
D. hirsuta 24
D. quaesita 24
D. Thwaitesii 24
D. Toposia 24
Dipsacaceae 22
Dipterocarpaceae .. 10
Dipterocarpus scabridus .. 10
D. zeylanicus 10
Discomycetae 137
Doona Gardneri .. 10
D. congestiflora .. 10
D. cordifolia, fruit eaten by monkeys 11
D. macrophylla .. 11
Dothiora Symploci Petch .. 137

E.

Ebenaceae 23
Elaeocarpus 13
Ellipanthus Thwaitesii .. 17
Emilia sonchifolia DC. Synchytrium fuscum Petch on 134
Endemic Flora, The Altitudinal Distribution of the .. 1
Endemic species, Altitudinal range of 14
Eriocaulon, Altitudinal range of 41
Eriocaulonaceae .. 40
Erythrina lithosperma, Fusarium on 275
E. lithosperma, Phoma on .. 276
Erythroxylon acuminatum .. 13
E. obtusifolium .. 13
Eugenia mabaeoides Wight, Hyponectria Eugeniae Petch on 134
Euonymus revolutus .. 15
E. Thwaitesii 15
E. Walkeri 15
Euphorbiaceae 35
Euphrasia Linn .. 146
Exosporium megalosporum Penz. and Sacc. .. 174
E. Arecae Petch .. 174

F.

Ficus 35
Freycinetia Walkeri .. 40

PAGE

Fungi associated with disease in Vanilla, The 181
Fungi, Revision of Ceylon .. 161
Fusarium disease of Dadap (Erythrina lithosperma), A. 275
Fusarium pulvinatum Sacc. 169
Fusidium Crataevae B. & Br. 171
F. fasciculatum B. & Br. .. 171
F. pulvinatum B. & Br. .. 176
Fusisporum pulvinatum B. & Br. 169

G.

Gaertnera Walkeri .. 27
Galvesia Juss 140
Garcinia echinocarpa .. 4
Garcinia, seeds animal carried 9
Gasparinia Endl. .. 154
G. admirabilis Hassk. .. 155
G. mirabilis Endl. .. 155
Gentianaceae 27
Geraniaceae 13
Gesneraceae 28, 145
Gleniea zeylanica .. 16
Gliocladium microsporum Petch 137
G. penicillioides Corda .. 138
Gloeosporium Bussei P. Henn, 182, 191
G. affine Sacc. 182
G. Colletotrichum on Vanilla 190
G. piperatum E. & E. .. 307
G. rufomaculans Thuem. .. 184
G. Vanillae Cke. 181, 182, 184, 191
Glomerella congulata Shear and Wood 188
G. Vanillae Petch and Rag. 191
Gloriosa superba .. 38
Glossostigma Arn. .. 146
Gnomoniopsis Vanillae Stonem. .. 152, 187, 191
Gordonia, Wind-carried .. 9
Graderia Benth .. 146
Gramineae 43
Gramineae, Altitudinal range of 42
Grewia diplocarpa .. 13
Grey Blight of Tea and Coconut 197
Guttiferae 9
Gymnosporia fruticosa .. 15
Gyrinops Walla .. 33

H.

Haematobanche Bresl. .. 158
H. sanguinea Presl. .. 158
Haematomyces carneus Petch 137
H. carneus Rehm. 137
H. cerebriformis Petch .. 137
Hainesia on Vanilla .. 181, 192
Harveya Hk. 146

	Page
Hibiscus, Hormactis rosea Petch on	172
Helicia zeylanica	32
Helicosporium recurvum Petch	138
Helminthosporium Arecae B. & Br.	173
H. atropurpureum B. & Br.	173
H. calicioideum B. & Br.	174
Helminthosporium gigasporum B. & Br.	172
H. Oryzae B. de H.	138
Henriquesia Ochlandrae Petch	137
Heptapleurum exaltatum	21
Heterothallism	244
Hopea cordifolia	11
H. discolor	11
H. jucunda	11
Haloragaceae	18
Hormactis rosea Petch	172
Hormiscium pulvinatum Petch	138
Hortonia	32
Hunteria corymbosa Trimen	140
H. Legocii Livera	140
H. Roxburghiana Thw.	140
H. zeylanica Gardn.	142
Hydnocarpus venenata, fruit water carried	9
Hydnum fragile Petch	134
H. fragile Fr.	134
H. scabrum Petch	134
Hydrocharitaceae	36
Hymenopsis atrocarneum Sacc.	177
H. tenuis Petch	178
Hyobanche Linn	158
H. atropurpurea Bolus	158
H. glabrata Hiern	158
H. robusta. Schönland	158
H. rubra N.E.Br.	158
H. sanguinea Linn	158
Hyphomycetae	137
Hyponectria Eugeniae Petch	134

I.

Impatiens elongate	14
I. repens	14
Introduction of species by Man	6
Isaria congesta B. & Br.	168
I. congregata B. & Br.	174
I. pulcherrima B. & Br.	172
Isonandra lanceolata	23

J.

Jak tree, Mycena farinosa Petch on	122
Julostylis angustifolia	13

K.

Kayea stylosa, seeds water carried	9
Klugia zeylanica	28
Kurrima zeylanica, fruit eaten by mynas	16

L.

Labiatae	30
Laestadia Traversi Cavara	194
Lantana aculeata	30
L. indica	30
Lantana, Trichosphaeria fasciculifera Petch on	135
Laschia ? pezizaeformis B. & C.	133
Lauraceae	32
Lauraceae, Altitudinal range of	33
Legocia Livera	153, 157
L. aurantiaca Livera	158
Leguminosae	17
Lepto-sphaeria depressa Petch	135
Leucocodon reticulatum	21
Lewis, F.—The Altitudinal Distribution of the Ceylon Endemic Flora	1
Liliaceae	38
Limosella Linn.	146
inaceae	13
Linociera purpurea	24
Livera, E. J.—Aeginetiaceae, A New Natural Family of Flowering Plants	145
Livera, E.J.—Some New Ceylon Plants	139
Loganiaceae	27
Loranthaceae	33
Loranthus, Altitudinal range of	34
Loxococcus rupicola	39
Lythraceae	20

M.

Maba acuminata	23
M. buxifolia	23
Macrophoma on Vanilla	184
Malvaceae	13
Mangifera indica Linn., Helicosporium recurvum Petch on	138
M. indica Linn., Zignoella tuberculata Petch on	135
M. zeylanica	16
Mango, Helicosporium recurvum Petch on	130
Mastixia tetrandra	21
Medinilla fuschsioides	20
M. maculata	20
Melastomaceae	19
Meliaceae	15
Melothria zeylanica	20
Memecylon	20
Menispermaceae	8
Mesua ferrea, forests of	7
M. Thwaitesii, water loving	9
Microtopis Wallichiana	15
Mimosa pudica	38
Momordica denudata	20
Moniliopsis sp.	169

PAGE

Monimiaceae 32
Monoporandra cordifolia .. 12
Monttea Gay 146
Munronia pumila .. 15
Mycena aculeifera Petch .. 132
M. clavulifer B. & Br. .. 162
M. citrinella P. .. 162
M. corticola Scjum. .. 163
M. dendrophila Petch .. 164
M. farinosa Petch .. 131
M. grisea Petch .. 132
M. heliscus B. & Br. .. 163
M. paediscula B. & Br. .. 162
M. rorida Fr. 132
M. tenerrima B. & Br. .. 132
M. tenerrima Berk .. 161
Mycosphaerella on Vanilla .. 194
Myristica laurifolia, fruit eaten by Hill Myna .. 9
M. Horsfieldia 32
M. zeylanica 32
Myristicaceae 32
Myrsineae 23
Myrtaceae 19
Myrothecium atrocarneum B. & Br. 177
M. Carmichaelianum Grev. .. 178
M. roridum Tode .. 178

N.

Naiadaceae 40
Nectria bogoriensis Bern. .. 183, 184
N. Bolbophylli P. Henn. .. 184
N. haematococca B. & Br. 184
N. peristomata Zimm. .. 183
N. tjibodensis Penz. and Sacc. 183
N. Vanillae Zimm. .. 183
N. Vanillicola P. Henn. .. 183
Nephenthaceae 31
Nepenthus distillatoria .. 31
Nipa fruticans .. 39

O.

Ocellaria Vanillae .. 182
Ochlandra stridula Thw., Henriquesia Ochlandrae Petch on 137
Ochnaceae 14
Ochna rufescens .. 14
Oedemium sparsum B. & Br. 175
Olacineae 15
Olax zeylanica 15
Olea polygama Wight, Aecidium Chionanthi B. & Br. on .. 166
Oleaceae 24
Oligopholis Wight .. 156
O. tubulosa Wight .. 150, 156
Oncosperma fasciculatum .. 39
Orchideae 36
Orobanchaceae .. 28, 145

PAGE

Orobanche acaulis Roxb. .. 155
O. Aeginetia Linn. .. 154
O. pedunculata Roxb. .. 154
Oryza sativa Linn., Helminthosporium Oryzae B. de H. on 138

P.

Palaquium grande .. 23
P. petiolare 23
P. rubiginosum 23
Palmaceae 39
Panax fruticosum Linn., Rhynchosphaeria sepulta Petch on 135
Pandanaceae 39
Pandanus odoratissimus, Podosporium sparsum Petch on 175
Pandanus zeylanicus .. 39
Parkia Roxburghii, Mycena clarulifer B. & Br. on .. 162
P. Roxburghii, Mycena paediscula B. & Br. on .. 162
Patana lands 3
Penicillium incarnatum B. & Br. 171
P. roseum Link .. 172
Penzigia microspora Petch .. 137
Periconia rigida B. & Br. .. 169
Pericopsis Mooniana .. 18
Pestalozzia Guepini Desmaz. 198
P. palmarum Cooke, 199, 211, 230, 236
P. Theae Sawada, 199, 223, 235
Petch, T.—Additions to Ceylon Fungi, IV. .. 131
Petch, T.—Revisions of Ceylon Fungi, Part VIII. 161
Petchia ceylanica Livera .. 140
Phelipaea cytinoides Reuter 158
Phelipaea subacaulis Benth. 155
Phoenix zeylanica .. 39
Phoma on Erythrina lithosperma 276
Phoma on Vanilla .. 182
Phragmidium on coconut .. 211
Phycomycetae 134
Phyllanthus 35
Physalospora Vanillae Zimm. .. 183, 184, 188, 191
Phyllosticta Vanillae P. Henn. 183, 194
Phytophthora Faberi, oospores of .. 243
Phytophthora species, Some Observations on the oospores of .. 243
Phytophthora species, strains used 245
Piperaceae 31
Piper peltatum 31
Pittosporaceae 9

	Page
Pityranthe verrucosa	13
Podosporium calicioideum Petch	174
P. sparsum Petch	176
Podostemaceae	31
Pothos, fruits bird-eaten	40
Polygalaceae	9
Polystictus flabelliformis, Gliocladium microsporum Petch on	138
Prer na procumbens	30
P. Thwaitesii	30
P. tomentosa	30
Proteaceae	32
Psathyra ctenodes Petch	165
Psathyrella ctenodes B. & Br.	164
P. disseminata P.	164
P. furfurella B. & Br.	163
Pseudocarapa Championii	15
Psidium Guajava spread by Cattle	6
Psilonia gilva Fr.	177
P. penicillata B. & Br.	170
Pyrenomycetae	134

R.

Ranunculaceae	7
Revisions of Ceylon Fungi, Part VIII.	161
Rhamnaceae	16
Rhamnus Arnottianus	16
Rhinanthus Linn.	146
Rhizoctonia solani Kühn, Some investigations into conditions affecting the parasitism of	259
Rhizophoraceae	18
Rhynchosphaeria sepulta Petch	135
Rice, Helminthosporium Oryza B. de H. on	138
Rosa sp., Sphaerella rosigena Ell. and Ev. on	134
Rosaceae	18
Rosellinia albocincta Petch.	167
R. catervaria Sacc.	167
R. caudata Petch	135
R. decidua Petch	136
R. immersa Petch	136
R. obtusa Petch	136
R. rhypara Sacc.	167
R. tenuistromicola Petch	136
Rubiaceae	21
Russelia Jacq.	146
Rutaceae	14

S.

Samydaceae	20
Sapindaceae	16
Sapindus erectus	16
S. Thwaitesii	16
Sapotaceae	23
Schizostigma	21
Schizostigma hirsutum	2
Schumacheria. Distribution of seeds by water	8
Schweinfurthia Braun	146
Scitamineae	36
Scitamineae, Altitudinal range of	37
Scrophulariaceae	27, 146
Scyphostachys	21
Serpicula zeylanica	18
Solanaceae	27
Sophora zeylanica	18
Sphaerella rosigena Ell. and Ev.	134
Sporotrichum lichenicola B. & Br.	167
Stemonoporus acuminatus	11
S. affinis	11
S. canaliculatus	12
S. Gardneri	11
S. Lewisianus	12
S. petiolaris	12
S. revolutus	12
S. Wightii	11
Stenosiphonium Russellianum	30
Sterculia Thwaitesii	13
Stilbum byssigena B. & Br.	179
S. byssisedum B. & C.	179
S. clavula B. & Br.	178
S. compressum B. & Br.	176
Striga Lour	146
Stachytarpheta indica	30
Styraceae	24
Sunaptea scabriuscula	11
Symplocaceae of Ceylon, notes on some	315
Symplocos eugenioides Livera	317, 318
S. obovata Wight and Gardner	317
S. spicata Roxb., Dothiora Symploci Petch on	137
S. versicolor Clarke	315
Synchytrium fuscum Petch.	134

T.

Talawa lands	3
Tea and Coconut, Grey Blight on	197
Tea, Helminthosporium gigasporum B. & Br. on	173
Terminalia parviflora	19
Ternstroemia emarginata water loving	9
Ternstroemiaceae	9
Thismia Gardneriana	36
Thymelaeaceae	32
Tiliaceae	13
Tournefortia Walkerae	27
Tozzia Linn.	146
Trichopus zeylanica	38

PAGE

Trichosanthes integrifolia, fruit eaten by monkeys 20
Trichosphaeria dactylosporifera Petch .. 134
T. fasciculifera Petch .. 134
Triumfetta glabra .. 13
Tronicena Steud .. 154
Trullula Vanillae P. Henn. .. 183, 191

U.

Umbelliferae 21
Uredo scabies 181
Urginea rupicola .. 38
Uromyces Joffrini Delacr. .. 183
Urticaceae 35

V.

Vanilla odorata Presl. .. 148
Vanilla, The Fungi associated with disease in .. 181
Vateria acuminata .. 11
Vatica obscura 10, 11
Vegetation of burst tank .. 42
Verbaceae 30

PAGE

Vermicularia capsici Syd. .. 308
V. Vanillae Delacr. 182, 187, 191
Violaceae 9
Vitex altissima .. 30
Volutella gilva Sacc. .. 177
V. penicillata Sacc. .. 170
V. Vanillae Petch and Rag. 187, 190, 191

W.

Walsura Gardneri .. 15
Westminster Abbey .. 7
Willughbeia zeylanica .. 25
Wind, action of on vegetation 4
Wormia triquetra .. 4
W. triquetra, Distribution of seeds by animals .. 8
Wrightia angustifolia .. 25
W. flavido-rosea .. 25
W. zeylanica 25

Z.

Zignoella tuberculata Petch 135
Zizyphus Napeca .. 16